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ABSTRACT

This report is based on interviews with a group of elementary school children about how they answered the items in an achievement test administered 12 months after a 7-week instructional unit. Data from the interviews are related to data from further pretests and posttests and from detailed observations and recordings of the original instructional unit. The evidence obtained is used to build up a model of how memory for instruction works in 9-year-old children and of how they use their knowledge and memory to answer achievement test items. It is argued that understanding what a child has learned from achievement test performance requires an appropriate theory of how learning and memory processes work in young children. Some principles of effective instruction are derived from the data. (Author/CM)

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Measuring and Understanding the Way Children Learn in Class

Graham Nuthall

and

Adrienne Alton Lee

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TM 820 737

Technical Report: Teaching Research Project

Education Department, University of Canterbury, Christchurch, New Zealand.

August, 1982

MEASURING AND UNDERSTANDING THE WAY CHILDREN LEARN IN CLASSROOMS

A study of what elementary students learn and remember from instruction and how they use this knowledge to answer achievement tests.

Graham Nuthall and Adrienne Alton Lee

August, 1982

Technical Report: Teaching Research Project

Education Department

University of Canterbury

Christchurch, New Zealand

ABSTRACT

This report is based on interviews with a group of elementary school children about how they answered the items in an achievement test administered twelve months after a seven week instructional unit. Data from the interviews is related to data from further pre and post tests and from detailed observations and recordings of the original instructional unit. The evidence obtained is used to build up a model of how memory for instruction works in nine year old children and of how they use their knowledge and memories to answer achievement test items. It is argued that understanding what a child has learned from achievement test performance requires an appropriate theory of how learning and memory processes work in young children. Some principles of effective instruction are derived from the data.

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This report is dedicated to Ana, Debbie, Guy, Hayley, Karl, Stephen and especially to Robin.

Copyright

Graham Nuthall & Adrienne Alton Lee

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INTRODUCTION

In the last thirty years, considerable progress has been made in the development of research on teaching effectiveness and pupil learning in the classroom. Observation and measurement procedures have been developed to the point where the objectivity and reliability of the data available for analysis is no longer a serious problem. It is now taken for granted that we can measure with considerable precision and objectivity what pupils may have learned as a consequence of instruction.

This belief is, however, based on the assumption that the validity or 'content' of achievement tests is well understood. It is usually claimed that what an achievement test is measuring can be seen quite clearly by examining the logic and content of the items. If any problems do arise they arise from failure of the items to sample adequately the 'domain' that the test is intended to assess, or from failure to describe that 'domain' in appropriately behavioural terms.

Sometimes additional supporting evidence from correlations between different test results is introduced and analyzed. But, however elaborate the procedure, it depends, at some critical point, on the assumption that an achievement test item always functions in the same way regardless of the context in which it might be used and that this function can be determined by direct inspection of the content of the item.

This assumption is, and always has been, fundamental to the use of tests as objective measures of achievement and learning in psychological and educational research. The test development movement of the 1930s and 1940s attempted to provide psychological research in education with the objective data base that it needed to progress as a science. It did so by taking item performance as the fundamental unit of objective evidence. Once a subject had completed an item (made a response), she or he was of no further

relevance to the interpretation of the results, or the uses to which the results could be put. It was the function of the researcher to penetrate the meaning of the subject's performance, and gain insight into the psychological functioning of the subject by more and more sophisticated manipulations of item performance or response data.

The researcher was permitted to define and analyze the psychology of test performance. That was considered objective and scientific. The subject could not be used to investigate her/his own psychology. That would have been considered subjective and unscientific.

In the last fifteen years, a major change has been taking place in the accepted procedures of psychological research on learning processes. The objective calculus of item performance is being supplemented, sometimes replaced, by inviting subjects to contribute to, and even participate in, the exploration of their own psychological processes. In research on classroom teaching this change has stimulated valuable new studies of the decision-making and thinking processes taking place in teachers at work. (Shavelson & Stern, 1981). But so far this reorientation has not had any impact on the measurement of learning or achievement in studies of teaching effectiveness.

One of the means by which progress can be made in an area of scientific research is by challenging the assumptions that currently underlie the research methods being used. It has been assumed, as an article of faith, that the content of the tests used to assess what children have learned in school can be determined by the logical and analytic procedures available to the researcher, without direct reference to the actual experiences of the children who took the test. This may have seemed a reasonable assumption, but it is one which should not remain unexamined.

The Purpose of this Report

The purpose of this report is to describe the results of a study in

which pupils were asked to discuss with an interviewer how they went about answering questions on an achievement test which had been designed to assess the effects of a seven week instructional unit in a Std 3 (9 year old) class. The test was administered three times: before, immediately after and one year after the instructional unit. The interviews were conducted after the third testing. The questions which guided our analysis of these interviews were:

1. What question-answering and memory processes do pupils use when answering achievement test items?

2. How do these processes relate to the pupils' actual performance on the items and the apparent content of the items?

3. What general information about the learning and memory processes of the pupils, and the effects of instruction, can be obtained from the answers to the two previous questions.

As the subsequent analysis of the interview and test data will show, it is not possible to separate an analysis of what an achievement test measures from the way pupils answer test questions and the way instruction affects their knowledge and memory for the relevant content. Any interpretation of a set of test scores implies some theory of learning and memory, no matter how naive. Getting pupils to talk about the way they answer test items is one way of testing the adequacy of this theory, and consequently the validity of the way the test results are to be interpreted.

The Nature of the Study

The interviews which have been used in this paper took place as part of a larger investigation of the relationships between classroom instructional activity and pupil learning being carried out at the University of Canterbury.*

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* Mrs Adrienne Alton Lee is responsible for the planning and management of this larger study.

This larger study involved detailed observation of a seven week unit of instruction in an open plan classroom with three teachers. This unit involved three related topics (erosion, pollution and the preservation of endangered species) under the general heading of 'conservation'. The pupils were at the Std 3 (9 year old) level. The design of the study involved (a) detailed observation and recording of all of the activities of three selected pupils, (b) more general observation and recording of the activities of the group of pupils under one teacher's immediate control, and (c) some monitoring of the behaviour of the other children in the three-class open space. Several tests were administered to all the pupils, and a selected sample of pupils were interviewed at intervals about their experiences and feelings during the 'unit'. Of immediate relevance to this paper is the main achievement test for the unit which was administered (a) before the seven week study unit began, (b) immediately after the unit was completed, and a third time, (c) twelve months after the second administration.

This achievement test consisted of 62 items (multiple choice and short answer) dealing with facts, concepts and principles covered in the unit. It was prepared in consultation with the teachers before the unit began, and matched very closely the actual content of the instruction and class activities that took place during the seven weeks. (Appendix E contains a copy of the test).

The interviews on which this paper is based, took place immediately after the third administration of the achievement test.

It is important to note that the unit consisted of a variety of instructional activities. For between one and two hours each day, during the seven weeks of the unit,* the children engaged in class discussions, listened to teacher lectures, carried out library research, watched demonstrations, organized a debate, listened to stories, created wall posters, and

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* The total time spent on the unit was 40 hours over 32 days.

so on. It was, by normal elementary class standards, a more imaginative and varied unit of work than usual, although there was, naturally, variation in the extent to which each part of it interested or involved all the pupils.

Subjects

Most of the data reported in this paper is based on the test performance data, and interviews obtained from six children (three boys and three girls). Three of these were the three who were selected for detailed study as part of the larger investigation. Detailed recordings and observations were made of all of their activities and work during the seven week instructional unit. In addition general recordings and observations were made of the rest of the class so that general class information was available for the activities and work of the other three children.

The six children were selected to represent a range of ability and achievement within the class. They also represented a range of involvement in class leadership and peer-directed activities.

The interviews with the children took from two to four hours each (not including appropriate breaks) and produced between 6,000 and 11,400 words of transcript each (average: 8580 words).

6

CHAPTER 1.

THE MEMORY PROCESSES THAT CHILDREN USE TO ANSWER ACHIEVEMENT TEST ITEMS.

In this chapter we describe the kind of memory that children have for past instruction, and the memory processes that children say they use when answering achievement test items. In the final section, this evidence is used to show that different children can use quite different memory processes when answering the same test items despite having experienced the same instruction.

1.1 Interview Procedure

The interviews used to obtain information on the children's item answering procedures involved the following procedure. The interviewer went through the achievement test with each child individually several days after it had been completed. The child had in front of her/him a blank copy of the test and the interviewer asked, for each item, what answer the child had selected, and what reasons or ideas had led the child to select that answer. The interviewer had the copy of the child's completed test in front of her so that she was able to check the child's interview responses against the earlier written responses.

Each child's interview responses were followed by probing questions to try to clarify, as far as possible, the source of the knowledge the child had used in answering each question and, where the answer was not immediately known, what procedures the child had used to try to deduce the correct answer.

This item by item questioning was preceded by general questions concerning the child's feelings about the test and her/his performance on it, and by questions designed to elicit any general recollections of the previous year's instructional unit. These preliminary questions functioned as a 'warm-up'

stimulating and focusing the child's memory.

1.2 General Characteristics of Memory

It was apparent from the children's responses to the interviews, that their memory for the content of the seven week unit of instruction was not a simple 'all or nothing' affair. There were several levels and types of memory that were evident when they were answering items in the achievement test.

At one end of the scale there was evidence of recall which was surprisingly complete and detailed. The following is an example of accurate recall of the content of a class discussion. The achievement test item which is the focus of this exchange was concerned with animals that destroy the New Zealand forest.

Interviewer: 'Opossum' destroys the New Zealand bush and forests. Why did you choose the opossum?

Pupil: Um, because of its claws, and eats bark and that, and it claws the trees and it, um, eats the roots and other trees, I think, and it would kill the trees.

Interviewer: Mm. Where did you learn, where did you learn that? How did you find that out?

Pupil: That was last year when we were talking about, um, endangered species and someone said 'the opossum' and Mr H asked them why they thought it was. And they thought that same reason (as above). And he asked who else thought that reason, and most people put their hands up.

Interviewer: You mean that the opossum was an endangered species because it was killing the trees or were the trees endangered?

Pupil: No. Yeah. They ... we were talking about endangered things that would be endangering ... you know, endangering other things.

Interviewer: I get it ...

Here it is evident that the pupil has answered the achievement test item on the basis of surprisingly accurate recall of the class discussion in which

the relevant content occurred. Recordings of the original discussion twelve months before indicate that the teacher was discussing "endangered species" when the name of opossums was raised.

Teacher:	... What's been the cause of them (native birds) becoming very close to extinction ... becoming endangered. What sort of things caused them to become endangered?
Pupil:	Opossums ... (noisy). Wild pigs ...
Teacher:	Well, what's that? What do you call those things?
Pupil:	Rodents?
Teacher:	The introduced animals. Thats one thing ...
Pupil:	Deforestation.
Teacher:	Why does deforestation cause, you know ...
Pupil:	Destroys their home ... (etc.)

The discussion moves onto the way introduced animals destroy native forest and hence the original habitat of the native birds. The pupil is thus correct in recalling 'opossum' in association with 'endangered species' even though there appears to be no logical association between the two.

Similarly detailed recall of other class activities also occurred. The following excerpt from an interview concerns the answer to an achievement test item about the meaning of the term 'introduced animal'.

Interviewer:	Right ... number ten?
Pupil:	Oh, well, like Captain Cook. I think he introduced pigs. 'Cause I remember in the library doing, um, that and well I think when other people brought them to the land ...
Interviewer:	Right ... well, um, do you remember Mr H talking about it at all? Introduced animals?
Pupil:	Um, no, I don't think I can, 'cause I remember because I was doing one about pigs and Captain Cook, and I remember that one especially. I don't think I can remember any one else.

The observations made twelve months previously contain a record of this

pupil spending time in the library searching for material about introduced animals and of her writing the following report:

Introduced Animals

> In 1773 Captain James Cook introduced animals to New Zealand. Now we are hunting wild pigs to get meat and skins. Captain Cook left pigs in New Zealand and they went wild ... (etc.)

However, memory for the source of the information that the pupil used to answer an achievement test item was not always as clear as this. Variation in the nature of pupil memory for the seven week unit of instruction is illustrated in the following five types of interview responses.

(a) Vague feeling of knowing

The most ambiguous and difficult response to interpret was the one in which the pupil expressed a feeling of having known or learned the information but was unable to recall it while answering the item. This 'tip of the tongue' experience is accepted as a legitimate phenomenon in experimental studies of memory, (Koriat & Leiblich, 1974) but it is difficult to know how to interpret it in this context. The following is a typical exchange of this kind:

Interviewer: Yeah, did you know that?

Pupil: Mm, no. I don't think I did ... nope ... But I think I learned that, um, before, but I couldn't remember, so I guessed.

(b) Context memory without content

Somewhat more definite than the type of recall described above, is recall of the occasion on which the content of the item was discussed while the content itself could not be recalled. The following exchange illustrates this type of recall:

Pupil: I wasn't too sure of that (answer).

Interviewer: Did you have any vague ideas about it at all?

Pupil: Um, I think I can remember Mr H saying about, um, oh, its ... oh, I've got the picture in my mind but I can't sort of say it ...

Interviewer: Is there a picture? Tell me about the picture.

Pupil: Um, something about, to do with roads and gutters, I think, or underneath roads, or um ...

Sometimes the context memory is quite vivid, although the relevant content remains obscure. The following exchange illustrates this phenomenon.

Interviewer: What about the hydrological cycle. Do you remember working on that?

Pupil: Yes.

Interviewer: Now what was that all about, and how did you do it?

Pupil: Um, well, Mr H um, drew it up on the board and explained it. And then we tried it and did it on brown (paper) copy and then on neat copy and, well, I missed most of it because I was at the dental (treatment by school dental nurse) ...

Interviewer: You were at the dentist, weren't you, and had to come back and have it. What happened then?

Pupil: Well, he explained it to the people who were at dental ... (Interview moves to another topic then reverts to this topic).

Pupil: ... Mr H did it on the blackboard on Tuesday ...

Interviewer: Did he? How did you know it was a Tuesday?

Pupil: Because I came back from the dental.

In terms of the distinction proposed by Tulving (Tulving & Donaldson, 1972) there is clear memory for episodic detail while memory for the semantic content has faded, or was never clearly stored in the first place.

(c) Fluctuating memory

It was important during interviews that the interviewer should avoid giving clues or prompts which would lead the pupil to an answer which did not reflect genuine recall. However, on occasions the interviewer was convinced from other evidence that the right prompt would elicit it. The following is an example of recall that finally emerges after persistent prompting.

Interviewer: Did Mr H teach you that?

Pupil: Yes, I think so.

Interviewer: How did he do it?

Pupil: Um, oh, I can't remember exactly.

Interviewer: Yeah. Do you remember anything about going to the 'flea-pit'? Do you remember about that?

Pupil: Um, I don't think so.

Interviewer: What about vacuum cleaning?

Pupil: Yeah! I remember that. I remember we had the thing with sand in it and water and we moved it around. And I think that was like, how it erodes. Instead of the winds, I think, its the sea. Ah, I remember with the vacuum cleaner how you do it, and we turned it on, and bits flew out, and that ... (etc.)

Here there appears to be a reasonably clear memory of the demonstration that the teacher used to show wind and sea erosion. Presumably that memory was functional when the pupil answered the relevant achievement test item, but it stayed beneath the level of conscious recall when the pupil was asked to describe the source of her test answer.

Sometimes the memory appears to fluctuate across the border between awareness and unawareness. In the achievement test used in this study there were three items that related to the 'hydrological cycle' by which water is transported through the stages of evaporation and precipitation. During the unit one teacher presented a diagram of this cycle on a chart, discussed it with the class, and asked the children to reproduce it. During an interview with one pupil it was apparent that he had forgotten this material entirely for one of the three items, was vaguely aware of it for another, and remembered it quite clearly for the third. On the latter occasion, it was the prompting of the interviewer that released an extensive and detailed description of the teacher's diagram.

(d) Memory of class activity without its point

On some occasions there is evidence that the memory for the relevant content is there, but not in the form needed by the pupil to answer the question. This might be because the content has become too generalized (lacking in detail) and necessary distinctions have been forgotten, or because the detail is still there but the purpose or conclusion of the activity has

been forgotten. The following transcript is an example of the former kind. The test item was concerned with the meaning of the word 'fauna'.

Pupil: I put native plants. I think, um ... oh, I can remember Mr H saying flora and fauna. I remember him teaching about that but I still get muddled up which one. And I don't know why I put native plants, but I just did.

An example of the latter kind can be seen in the following exchange. The interviewer uses a prompt to elicit recall of an activity in which the teacher demonstrated the effects of air pollution.

Interviewer: Do you remember the incense?

Pupil: Yeah.

Interviewer: Now, why did he do that? ...

Pupil: Well, we went into the 'flea-pit' and everyone was all smelling and everyone was going 'Oh God!' and all that, and we were looking on top of the door, and it was all put around the top of the door and everything. It was all up there.

Interviewer: Why was it there? What did it make you think of?

Pupil: Um ... Some people thought it didn't smell very nice, some people thought it smelled like flowers and chat, and, um, some people just didn't like it and went outside and that sort of thing.

Interviewer: Did it have anything to do with conservation?

Pupil: I think it did. I'm not sure, and I can't remember.

(e) Confused recall

As will become apparent in the next section of this paper, pupils sometimes answer questions on the basis of available knowledge (memory) and sometimes they work out the answer by inference or deduction from other related knowledge. Generally recall and deduction work together supplementing and complementing each other in the item answering processes which the pupils reported. However, on occasions they appear to work against each other producing contradictory results. In the following example, recall appears to have finally prevailed over a contradictory deduction. The test item is concerned with the hazards of being a wingless bird.

Interviewer: ... You first of all put: 'they are small', and then changed your mind and put: 'animals can eat their eggs'. Now what happened there?

Pupil: Um, I decided to put 'animals can eat their eggs', and ... I was just looking and, um, thought it might be 'because they are small' and they, um, can't get around the place and that. Then I decided to put that 'animals can eat their eggs' and that ...

Interviewer: Do you remember learning it, or did you just think that out, work that out?

Pupil: Um, I think we'd learned it and we'd done, um, a thing on. I think it was the rat or something eating the eggs of the Kiwi, and that would mean the Kiwi eggs wouldn't hatch and then the Kiwi that had (laid) the eggs would die soon and then there would be none of that family of Kiwis left.

(f) Relevant association

Occasionally when a pupil attempts to recall the source of information, associated experiences other than the one which is directly relevant may be reported. Presumably related experiences would normally be clustered by association in memory, and would come to mind when a pupil was attempting to describe a specific item-answering experience. However, it is likely that pupils did not report such associations because they did not believe they were what the interviewer was looking for. Occasionally, however, a pupil did reveal such associated experiences as he searched for the relevant one. In the following example, the test item being discussed concerns the meaning of 'deforestation'. During the unit there were two occasions when the preservation and destruction of forests were discussed. The pupil recalls both but is aware that one is an irrelevant occasion.

Pupil: Oh, yeah. I just worked it out from the word, because, um I know what the word means. I learned the word, see.

Interviewer: Do you remember learning the word?

Pupil: Yeah, they told us about it.

Interviewer: How did they tell you?

Pupil: They had this, um ... oh, no, I can't remember really. I don't think.

Interviewer: Did it just go out of your mind?

Pupil: The thing I was going to say is that ... oh ... we had this thing in the 'flea-pit' where Mr H took us, and there was three people who made things ... (describes a debate between pupils representing manufacturers and pupils representing conservationists, over the use of forests).

Interviewer: Mm. Did you decide anything?

Pupil: No, just arguing.

Interviewer: And is that where you learned 'deforestation'?

Pupil: Well, um, no. That was a different time.

Interviewer: Oh, was it? Do you remember what that one was?

Pupil: Um, deforestation, they, he (Mr H) talked to us in a group and, um, he said that it is taking away some of the little trees and the big trees ... (describes tree-culling forest management procedures).

Interviewer: And that's what 'deforestation' means.

Pupil: Yeah.

1.3 A Model of Memory for Instructional Activities

The pupils' responses to questions about their recall of the seven week unit suggest that their memory for instruction might be represented by the two dimensional model depicted in Figure 1. In this model, the horizontal dimension represents the variety of different aspects of instructional activities which are stored in memory by the pupils. Not only do they remember what is said (or what they read) but also much of the detail of the physical aspects of the events and activities. There is evidence for memory of who did what, and when; of diagrams and pictures and where they were located; of interruptions and arguments and teasing; and of many of the other peripheral details of daily life in the classroom.

The vertical dimension represents the layers that lie behind the surface detail of the events. The processes of understanding and thinking which are stimulated or required by the original instructional activities generate new

ideas, meanings, concepts and inferences. The information which is presented, discussed, or read about in class, interacts with the pupils' existing knowledge and skills and becomes progressively summarized and abstracted. This second dimension is very similar to the episodic-semantic distinction first proposed by Tulving (Tulving & Donaldson, 1972). While it is viewed in this model as a continuum rather than a distinction (as in Naus & Halasz, 1980), the descriptions of episodic and semantic memory which Tulving has provided apply to the different levels suggested in Figure 1.

It is important to note, however, that Figure 1 is not intended to represent what pupils actually recall. It is possible that if one could examine in detail a pupil's memory immediately after some instructional episode (which the pupil understood and participated in fully) then it would be possible to find material stored in all of the cells represented in Figure 1. However, with the passage of time memory fades and some of the material disappears or becomes integrated with other material (cf. Bransford & Franks). It is often claimed that detail disappears first leaving more and more abstract and generalized material until the whole episode becomes absorbed into existing cognitive structure (e.g., Ausubel, 1968; Kintsch & Bates, 1977). Evidence from the pupils' responses to interviews in this study, suggests that memory loss is much more piecemeal. As examples presented in the previous section of this paper indicate, detail of an activity can be retained when the purpose of that activity has been forgotten. Sometimes, of course, it was never understood in the first place.

This suggests that when it comes to answering items in an achievement test, the pupil has available a patchwork memory of the original instructional activities, something like a three-dimensional jig-saw puzzle with numerous parts missing. If the pupil is lucky, or the instruction has been effective, then the piece needed to answer the item correctly will be there. If not, then she or he must reconstruct, from the pieces that are there, what the

FIGURE 1

STUDENT MEMORY FOR CLASSROOM INSTRUCTION

	1. VERBAL MEMORY	2. MEMORY FOR CONTEXT & ACTIVITY	3. VISUAL MEMORY, IMAGERY
1. EPISODIC MEMORY	1.1 Details of what was said, read, written on board	1.2 Details of activities and physical location, time, actors	1.3 Details of diagrams pictures, demonstrations displays, films
2. SEMANTIC MEMORY	2.1 Concepts, ideas meanings of words, facts, numbers	2.2 Purposes and meanings of activities, events, interactions	2.3 Purposes and meanings of visual materials, images, spatial concepts
3. COGNITIVE STRUCTURE	3. Generalizations, abstract concepts interpretations, inferences, general ideas		
	4. Background knowledge, beliefs, attitudes, cognitive skills		

missing piece must have been like. This reconstruction may or may not be correct depending on the reliability of the pieces that are present and on the pupils' skill at making appropriate inferences.

One further point is suggested by the responses to the interviews. Frequently pupils could indicate how they worked out an answer to an item using knowledge which they had available. They could not however indicate anything about where that knowledge came from. They said it was something they 'just knew'. In some cases there was external evidence from the larger investigation that the relevant information was presented during the seven-week instructional unit, and that the pupil was involved in the instruction at the time. This suggests that, when all memory for the detail of an instructional activity is lost, the knowledge acquired during that activity becomes part of the 'general knowledge' that a pupil possesses and is no longer identifiable with its source.

Further discussion of the forgetting processes that occur with memory for instruction must await a more detailed analysis of the pupils' interview protocols. As later sections of this paper will indicate, it is the relationship between the pupils' interview responses and the pattern of their test answers that reveals most about the way their minds process and retain what they have learned.

1.4 The classification of Pupils' Item-answering Processes

The major reason for interviewing the pupils was to try to find out what they thought they were doing when they selected answers to achievement test items. To what extent were their answers based on complete or incomplete recall, or on other knowledge or processes? The interview protocols were examined in detail to try to determine:

(a) whether the pupil had available the information needed to answer the item, or whether she or he had inferred or deduced the answer from other knowledge, and

(b) whether the information the pupil did use came from recall of the seven week instructional unit on conservation, or came from other experiences.

Clearly it was rarely possible to make these distinctions with any certainty. Occasionally vivid recall of detail made the source of the knowledge reasonably easy to identify, but mostly the pupil's own assertions about where and how they had learned the material had to be depended on. Consistencies and inconsistencies between different items, and the match between pupils' recall of class events and what was known about these events from direct observation provided additional information about the nature of the pupils' memories and perceptions.

Figure 2 contains a list of the categories that were developed to classify the pupils responses to the interviews. A more detailed description of each of the categories, with illustrative examples from the interview protocols, is contained in Appendix A.

Categories 1, 2, and 4 describe responses which indicated that the pupil had answered the question primarily on information obtained from sources other than the seven week unit on conservation. Categories 5, 7, 8 and 9 include responses which contained evidence that recall of the activities or content of the unit on conservation was the major source of information. Category 10 includes responses where the pupil specifically referred both to recall from the unit on conservation and information from other sources.

In some cases, the pupil appeared to have known the answer more or less directly, and in other cases appeared not to have known the answer but to have worked it out by inference from other related information, a process which may have involved the elimination of incorrect alternatives. Category 5 contains responses indicating deduction from recall of relevant information from the conservation unit, and Category 4 contains responses suggesting deduction based on information from other sources.

Category 3 includes responses in which it was clear that the pupil had

FIGURE 2. CLASSIFICATION OF PUPIL DESCRIPTIONS OF HOW THEY ANSWERED ACHIEVEMENT TEST ITEMS.

1. Knowledge from other sources Answer is known from other non-school source or experience.

   1.0 Source of information not identified

   1.1 Answer from other sources (e.g., T.V, reading)

   1.2 Information from out-of-school experiences.

2. Knowledge from other school experiences Answer is known from lessons or school learning activities other than the unit on conservation.

3. Deduction from general knowledge. The answer was not known directly, but the pupil appeared to have inferred it from his or her own knowledge. The pupil cannot, however, identify the source of the knowledge.

4. Deduction from knowledge from other sources. The answer was not known directly, but the pupil was able to infer it from knowledge or cues from identified sources other than the unit on conservation.

   4.1 Deduction from knowledge obtained from other sources. (e.g., T.V, other lessons)

   4.2 Deduction from clues in the question itself. (e.g., careful use of question wording, elimination of incorrect alternatives).

5. Deduction from information learned during class project. The answer was not known directly but the pupil was able to deduce it from knowledge recalled from the unit on conservation.

   5.1 Deduction from vague or general memory of class discussion or

activity.

5.2 Deduction from recalled class discussion or activity.

6. Guesses and Deductions based on irrelevant considerations

The pupil appears to have guessed rather than deduced the answer, or has selected an alternative on erroneous or irrelevant grounds.

6.1 Guessing for test taking reasons

6.2 Answer based on lack of understanding or misunderstanding of the question.

6.3 Guesses with no explanation.

7. Learned during class project: visual. Answer is based on recall of picture, diagram or demonstration which was part of the eight-week unit on conservation.

8. Learned during class project: memory for activity or learning context

Answer is based on recall of an activity in which the pupil was involved or recall of the physical context of a learning activity which was part of the eight week unit on conservation.

8.1 Memory for dramatic activity or actions

8.2 Memory for learning context or learning activity.

9. Learned during class project: memory for discussion or 'being told' or reading

Answer is recalled from class discussion or what someone said or read during the eight week unit on conservation.

9.0 Recalls hearing information but not how or where.

9.1 Recalls general nature of the discussion, or having read in

book in library or class.

9.2 Recalls specific details of class discussion.

10. Interaction of knowledge learned during class project and knowledge from other sources. Answer is based on knowledge from other sources and from recall of the eight week unit on conservation where the pupil identifies both sources specifically.

10.1 Information from class project and out-of-school sources.

10.2 Information from class project and other school experiences.

11. Unintentional or careless errors. During the interview the pupil identifies his answer as an error or an answer that he didn't intend to give.

12. No memory for doing test item. Pupil cannot recall answering the item, or anything about the answer given.

13. Inadequate information. The information in the interview protocol is uninterpretable or non-existent.

13.1 Interviewer fails to ask pupil.

13.2 Pupil gives no answer or answer uninterpretable.

14. Item not answered on test.

worked out the answer from other knowledge, but it was not clear where that knowledge had come from. Sometimes the information being used was information which had been taught during the seven week unit, and sometimes it was not. But the pupil was apparently unaware of this and talked as though it was just something she or he knew or had worked out while doing the test item.

The subcategories within each category generally provide for more detailed classification where there was sufficient information to make reasonable distinctions. Two of these should be specially noted. Subcategories 1.0 and 9.0 represent responses where the pupils own claim is the only evidence on which to make the classification. For example, if a pupil claimed that he had recalled the answer from the unit on conservation, but could give no further information on how he learned it or the nature of the learning activity that occurred at the time, then the response would be included in subcategory 9.0. Thus, these two subcategories (1.0, and 9.0) are the ones that should be treated with the greatest caution.

The results of classifying the interview responses of the six children who were interviewed are reported in Table 1. The amount of agreement between the children's responses to each item has also been reported in Table 1.

The percentages in the right hand column of Table 1 indicate that the children described the unit on conservation as the source of their knowledge for answering about 31% of the test items (total of the three 'LEARNED' categories). On a further 3% of the occasions they reported using what they had learned in the unit as the basis for working out the answer (DEDUCTION from learning in unit). In addition, memory for the conservation unit is included in the responses which have been classified as both learned and known. When all of these are added together, memory for the conservation unit is involved in answering nearly 40% of all the items.

The first three categories in Table 1 contain responses in which other

TABLE 1

DISTRIBUTION OF CHILDREN'S INTERVIEW RESPONSES

Type of interview response	Response to item agreed by: * Four or more	Three	Two	Only one	Number of Responses	Percent of Total
KNOWN: from other sources	9	21	37	33	43	12.6
KNOWN: from other school experience	26	16	21	37	19	5.6
DEDUCTION: from other knowledge	35	22	17	26	82	24.0
DEDUCTION: from learning in unit			18	82	11	3.2
LEARNED: in unit from visual materials	41	14	27	18	22	6.4
LEARNED: in unit from activities			40	60	10	2.9
LEARNED: from discussion or reading	5	28	38	28	74	21.6
LEARNED and KNOWN		16	32	53	19	6.7
GUESSED	26		9	65	23	6.7
OTHER RESPONSES					39	11.4
Average percent:	18.8	18.8	27.1	35.3		

* Figures in the body of this table represent the percentage of those who made each type of interview response.

experiences are mentioned as the source of the knowledge used in answering the item. In just over half of these cases, the child reported working out the answer from 'general knowledge' or from other related knowledge. For the remainder, the answers were known from outside school sources (TV, reading, etc.) or from other school experiences. In all, 42% of the items were answered on the basis of knowledge apparently obtained from sources other than the conservation unit.

The remaining items were either guessed or answered on the basis of irrelevant considerations (6.7%), or were items for which insufficient information had been obtained from the interview to classify them sensibly (11.4%).

Table 2 describes the range of individual differences between the six children. Two children (G. and D.) reported very little use of knowledge obtained from out-of-school experiences, and one of them (G.) reported many more recollections of the unit on conservation than the other children. Two children (A. and D.) report relatively high levels of guessing. When these responses are added to those included in the 'other' category (items omitted or the child couldn't recollect giving any answer) these two children gave no justified responses to 15% to 20% of the test. As information presented later will indicate, these were the two children with the lowest scores on the test, although, it should be noted, not the children who learned the least.

Table 3 contains a more detailed breakdown of the children's use of memory for the content of the conservation unit. It is evident from this table that the most common description of using knowledge learned in the unit was one in which the child gave only a <u>general</u> description of the content of a class discussion. (10.5% of all interview responses). The next most frequent were responses in which the child claimed that the information was learned in class discussion during the unit, but the child was unable to provide a specific reference to the actual discussion (7.6%). Recollection

TABLE 2

DISTRIBUTION OF INDIVIDUAL CHILDREN'S INTERVIEW RESPONSES*

Type of Interview Response	Percentage of each child's responses: H.	G.	S.	K.	D.	A.	All children
Known from other sources	16	4	14	19	5	18	12.6
Known from other school experiences	4	4	12	4	7	4	5.6
Deduction from other knowledge	21	21	28	30	26	18	24.0
Deduction from unit learning	2	5	4	4	5	-	3.2
Learned in unit from visual material	2	16	4	7	4	7	6.4
Learned in unit from activities	5	5	2	-	5	-	2.9
Learned from discussion or reading	21	23	21	18	23	25	21.6
Learned from unit and also known	14	5	7	4	4	-	5.6
Guessed	5	2	4	5	9	16	6.7
Not asked	9	14	2	7	7	7	7.6
Other	1	1	2	2	5	4	3.8

* In this and subsequent tables, the six children are identified by the initial of their first name: viz. H., G., S., K., D. and A.

TABLE 3

CHILDREN'S INTERVIEW RESPONSES INVOLVING
MEMORY FOR CLASS ACTIVITY AND DISCUSSION

	Number of Responses: Child's Name: H.	G.	S.	K.	D.	A.	Total	Percent of all Responses
7. Visual Memory for diagram, demonstration, etc.	1	9	2	4	2	4	22	6.4
8.1 Memory for dramatic activity, mime, etc.	1	1	-	-	1	-	3	0.9
8.2 Memory for learning activity, e.g., drawing, writing	2	2	1	-	2	-	7	2.0
9.0 Memory for learning information during project, but non-specific	7	1	3	2	6	7	26	7.6
9.1 Memory for general nature of relevant discussion or reading	5	7	6	5	6	7	36	10.5
9.2 Memory for specific content of discussion or reading	-	5	3	3	1	-	12	3.5
Total	16	25	15	14	18	18	106	31.0

of the detail of what the teacher or other children said during a relevant discussion was relatively rare (3.5% of all responses).

Again, it is apparent from Table 3 that there were interesting differences between the six children in their patterns of recollection, as well as in the total number of times they claimed that class discussion or activities were the basis on which they answered the questions. One child (G.) recalled more about class activities than the others (see total number of responses at the bottom of Table 3. The frequency with which he described memory for visual aspects of the unit (diagrams, demonstrations etc.) was especially high. He was also able to recall specific details of the class discussion more frequently than the others. (See example, p.7 above). Such recall of detail did not occur at all with two of the children and occurred only once for a third child. However, because the total number of recollections of class discussions is very similar for each child (range: 10-14), the level of detail reported may be partly a function of the interview itself rather than the quality of the children's memories.

What is not apparent from Tables 2 and 3 is the degree to which children reported using the same memory process (or source of knowledge) for the same items. Data relevant to this question has been included in Table 1.

In the body of this table, the percentage of occasions when different numbers of children gave the same kind of interview response to the same test item, has been reported. The average percentages along the bottom of the table indicate that of all the children's interview responses, 18.8% were occasions on which four or more of the six children had given the same type of interview response to the same item.* A further 18.8% were occasions on which three of the six children gave the same interview response, and 27.1% were occasions on which only two children had given the same response. 35.3%

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* For example, they all reported they used 'DEDUCTION from other knowledge' as the source of their answer to a test item.

of the children's responses were unique, i.e., no other child had given the same type of interview response to the same item. If there had been perfect agreement between the children, then 100% of the responses would have been agreed by four or more children. If their responding had been entirely random, then 100% of responses would have been unique. (With 9 response categories and six children, the expected average number of responses per category for each item would be 0.67).

Thus there was a significant amount of agreement between the children over what was involved in answering an item, but also considerable disagreement. Nearly two thirds of the children's responses were the same as only one other child, or no other child.

It is interesting to note, however, that children's responses tended to be in greater agreement for recollections of the use of visual materials and for descriptions of having worked out the answer from other knowledge. By contrast, the amount of agreement between children in reporting memory for class discussion tends to be quite low. As data presented later in this report will indicate the children's answers to the test items related to one particular diagram and to two teacher demonstrations seems to reflect the significant impact these visual aspects of the unit had on the children's learning as well as on their recollection of the unit.

1.5 Summary and Comment

The six children interviewed reported that they answered about 40% of the test items on the basis of memory for what they had learned during the conservation unit, and 42% were answered on the basis of other knowledge. Within these categories, about 55% of the answers were reported as 'known' and 27% were described as having been 'deduced' from related knowledge.

There were, however, considerable individual differences within this pattern. One child reported memory for relevant class learning in answering

less than 30% of the items while another child reported memory for class learning in answering more than 50% of the items. One child reported deducing 34% of the answers while another child reported deducing only half that number (18%).

When the children's interview responses were compared across the 51 items for the nine different categories of response, it was clear that there was some general agreement in the processes involved in answering an item, but a good deal of disagreement. The children were in general agreement for about one fifth (19%) of the items. But for more than a third of their responses (35%) they agreed with no other child.

Agreement between the children on the processes involved in answering the test items tended to be higher when they reported recall of visual materials used in the conservation unit, and when they reported deducing the answer from other related knowledge or cues. They tended to show least agreement when they reported memory for class discussion.

This data raises the question of the validity of classifying items by the type of knowledge or cognitive activity that the items are intended to measure. One of the more usual distinctions is between items which measure 'facts' or 'recall' and items which require the student to 'apply' other knowledge or 'work out' the answer from related knowledge. This is the distinction between the first level of Bloom's Taxonomy and the second, third and fourth levels.

It is possible to argue that what an item measures is a function of the way the item is written, and the relationship between the item content and the content of the instruction or related experiences a child might have had. In this study, all the children experienced the same seven week instructional unit. They all took the same test at the same times. If the items determined the children's answering processes then there should have been a reasonably high degree of agreement between the children in their interview

responses. Table 1 indicates that this was not so.

It might be argued, however, that the categories developed for classifying the interview responses were unnecessarily or irrelevantly detailed for this kind of analysis. It might be more appropriate to consider agreement between children when the processes are classified within much broader categories that reflect the major item differences described above. (Recall vs. others).

Table 4 reports the results of classifying children's interview responses into three major categories: (a) the answer was known from sources other than the conservation unit, (b) the answer was learned during the conservation unit, and (c) the answer was worked out or deduced from other knowledge. The first two categories contain the responses that would be expected if the items involved only 'recall' of information learned or use of known 'facts'. The third category contains those responses which reflect 'higher level' processes.

It was clear, in preparing Table 4 that the children's responses were widely distributed over the three categories for most items. In only 10% of the items did the children all agree on the process involved in answering the item.

There were, however, degrees of disagreement. Category 4.1 (known mostly + learned) includes items in which about 80% of the children said they 'knew' the answer and 20% said they learned it. Category 4.3 (Learned mostly + known) included items where about 80% of the children said they learned the answer and 20% said they already knew it.

If the categories in which a majority of the children agree on one process (categories 4.1, 4.3, 5.1, 5.3, 6.1, 6.3 in Table 4) are added to those in which there is total agreement (categories 1, 2, 3 in Table 4) then there are 45% of the items on which the majority of children were agreed about the process involved in answering.

TABLE 4

STUDENT AGREEMENT ON PROCESSES INVOLVED IN ANSWERING TEST ITEMS

Pattern of Interview Response	Number of Items	Percent. of Items
1. All students report known*	-	-
2. All students report learned*	2	4
3. All students report deduced*	3	6
4. Students report known and learned		25
4.1 Known mostly (80%) + learned (20%)	2	
4.2 Known + learned equally	4	
4.3 Learned mostly (80%) + known (20%)	7	
5. Students report Learned and Deduced		29
5.1 Learned mostly (80%) + deduced (20%)	3	
5.2 Learned + deduced equally	7	
5.3 Deduced mostly (80%) + learned (20%)	5	
6. Students report Known and Deduced		4
6.1 Known mostly (80%) + deduced (20%)	-	
6.2 Known + deduced equally	1	
6.3 Deduced mostly (80%) + known (20%)	1	
7. Students report known, learned and deduced	13	25
8. Others (not interviewed, etc.)	3	6

* Known includes known from other sources and known from other school experiences. Learned includes all categories of Learned from the unit on conservation. Deduced includes Deduction from other knowledge and deduction from unit learning. (See Figure 2 for full descriptions).

It might also be argued that the distinction between 'known' and 'learned' is not a significant one as far as item type is concerned. The major distinction is between those items for which the answer was known or recalled and those items for which the answer was not known and had to be worked out. In this case the items included in category 4.2 (known and learned equally) should also be included among those classified as 'agreed'. This raises the percentage of items on which the children are in agreement to 53%.

On this latter, more conservative interpretation, there were still 41% of the items on which the children were clearly divided as to whether they knew or recalled the answer, or deduced it from related knowledge.

Thus, if the children's reports are to be believed, there is a relatively large proportion of the items which are measuring different processes in different children. If a more detailed analysis of children's responses is used, the proportion is significantly higher. If the specific type of information that a child reports using within a specific type of item-answering process, is also considered, then it is rare to find two children describing their answering process for the same item in exactly the same way.

CHAPTER TWO

PUPIL PERFORMANCE ON THE CRITERION TESTS

Before relating the children's interview responses to their actual test performance we found it necessary to develop more sensitive methods of item score analysis that would provide a more detailed picture of what the children had actually learned during the instructional unit.

This chapter describes the methods we developed for identifying from test item scores what each child had learned and how effective the teacher had been in teaching the material relevant to each item. Total test scores are not only relatively insensitive measures of what was learned and what was not learned during a unit of instruction, they can also be misleading indices of how much a given child has learned. As one author has argued in a previous paper (Nuthall, 1978) there is good reason to believe that if all of the items on an achievement test are not measuring the same achievement, or that different children have learned different aspects of the knowledge area being measured by the achievement test, then the total test score may not be capable of measuring the effects of instruction at all.

2.1 Patterns of Achievement Test Item Performance

As we indicated previously, the children in this study completed a specially designed achievement test three times. The first time was before the unit of instruction began. The second time was immediately after the instructional unit, and the third time was approximately one year after the second test. This meant that, for each child, there were three scores for each test item: a pretest score, an immediate post-test score, and a delayed post-test score.

A child could be right or wrong on any of these three occasions, producing 8 possible combinations of correct and incorrect responses.

FIGURE 3

THE CODING OF CHILDREN'S ITEM ANSWER PATTERNS

Code	Pretest	Posttest	Year Later	Description of Pattern:
A	✓	✓	✓	Known before teaching: not forgotten
B	✓	✓	×	Known before teaching: forgotten later
C	{ ✓	×	✓ }	Known before, but wrong following teaching
	{		}	
	{ ✓	×	× }	
D	×	✓	✓	Taught during unit: long term effect
E	×	✓	×	Taught during unit: short term effect
F	×	×	✓	Not taught, but learned later
G	×	×	×	Not taught and never learned

TABLE 5

DISTRIBUTION OF TEST ANSWER PATTERNS FOR EACH CHILD

(Total number of items = 51)

Pattern of Test Answers Code Description	Number of Test Items for each child							
	H.	G.	S.	K.	D.	A.	Total	Percent
A. Known: not forgotten	32	30	22	22	19	13	138	45.1
B. Known: and forgotten	1	2	1	1	-	2	7	2.3
C. Known with teaching error	1	1	2	3	2	5	14	4.6
D. Taught: long term	8	10	13	16	11	14	72	23.5
E. Taught: short term	2	2	8	4	3	7	26	8.5
F. Not taught: learned later	2	3	1	2	7	5	20	6.5
G. Not taught: never learned	5	3	4	3	9	5	29	9.5

TABLE 6

INDIVIDUAL DIFFERENCES IN CHILDREN'S ITEM ANSWER PATTERNS*

Pattern of Test Answers Code Description	Percentage of each child's test answers H	G	S	K	D	A	Average Percent
A. KNOWN: not forgotten	63	59	43	43	37	24	44.8
B. KNOWN: and forgotten		4	2			4	1.6
C. KNOWN: with teaching error	2	2	4	6	2	10	4.2
D. TAUGHT: long term	16	20	25	31	20	25	23.2
E. TAUGHT: short term	2	2	14	6	4	10	6.2
F. NOT TAUGHT: learned later	2	6	2	4	10	10	5.2
G. NOT TAUGHT: never learned	10	6	6	4	18	4	7.8
GUESSED (on third test)	6	2	4	6	10	14	6.9

* In this table those test answers which a child indicated, in the interview, had been guessed, have been removed from the data in the body of the table and reported in the bottom row.

Figure 3 contains a list of these 8 combinations and the way they were grouped and described for analyzing the children's test score patterns.

The frequencies of these test answer patterns for each of the six children who were interviewed after the third testing, are set out in Table 5 and represented as percentages of each child's total test performance in Table 6. The data in Table 6 has been corrected by removing from the main body of the table those items for which the children indicated, in the interview, that they had guessed the answers. The frequency with which children reported guessing, and the relationship of this guessing to the different patterns of test answers, is set out in Table 7.

2.1.1 Pattern of Test Answering. The data in Table 5 indicates that for the teaching and testing situation involved in this study, the children had considerable prior knowledge. Fortyfive per cent of the items were answered correctly before the unit began and continued to be answered correctly through the immediate and delayed post-test. Another two per cent were answered correctly before and after the teaching, but not one year later. A further third of the items (32%) appear to have been unknown before the teaching and known immediately afterwards. Of these items, about three quarters were still answered correctly one year later, and one quarter had been forgotten. About sixteen per cent of all items were not answered correctly before and after teaching.

It should be noted that this test was designed to reflect as accurately and completely as possible the objectives which the teachers had in mind when they planned the eight week unit of instruction. It was designed to be valid to the teachers' descriptions of the content of the unit and not necessarily ideal with respect to indices of item difficulty and discriminative power.

Thus, the fact that children answered half of the items correctly before

the unit began reflects the fact that the children knew, before instruction, about half of the material that the teachers intended covering in the unit. This does not mean, however, that half of the teaching was a waste of time. There are two important reasons why this was not so. First, the half of the items which were correctly answered before instruction were not the same items for each child. As will be evident from data presented later in this paper, there were a much smaller number of items which were already known by all children. Second, the small number of items which were known by almost all children covered concepts and information (e.g., the meaning of the word 'pollution') which were basic to an understanding of the greater part of the unit. These items dealt with material which the teachers wanted to make sure all of the children knew before they could proceed through the unit.

2.1.2 Patterns of Guessing. Table 7 shows the relationship between the guessing identified in the interviews and the different test answer patterns. The first point to note is that the frequency of guessing is relatively low. In the interview, children were asked to describe, with a blank test booklet in front of them, which answer they gave, why theygave that answer, and where the information they used had come from (e.g., 'How did you know that?') Responses were classified as guessing when the child seemed unable to give any reason for the answer or gave a reason which didn't relate in any sensible way to the relevant content of the item. This meant that the onus of proof was on the child (although in the interview itself, every effort was made to let children know that any response they cared to make was equally acceptable and interesting to the interviewer). With this procedure, there were probably some occasions on which children could no longer remember the reasons for their answers, or could not articulate the evidence they had used and consequently said they had guessed when they had not. Thus seven per cent is probably an over-estimate of the amount of guessing that did take place.

TABLE 7

RELATIONSHIP OF GUESSING RESPONSES TO TEST ANSWER PATTERNS

Pattern of Test Answer	Frequency of guessing reported in interview Child's name:						
	H.	G.	S.	K.	D.	A.	Total
A. Known: not forgotten						1	1
B. Known: and forgotten	1			1			2
C. Known with teaching error					1		1
D. Taught: long term					1	1	2
E. Taught: short term	1	1	1	1	1	2	7
F. Not taught: learned later	1				2		3
G. Not taught: never learned			1	1		3	5
Total	3	1	2	3	5	7	21

The second point to note is that the guessing responses were not randomly distributed across test answer patterns and did not produce equal numbers of right and wrong answers. Most guesses produced wrong answers (67% wrong) and most occurred in the two categories 'E. Taught : short term' and 'G. Not taught : never learned'.

2.1.3 Individual Differences between Children. The data in Table 6 reveal some of the marked differences that occurred between the test answering patterns of the six children. First, there was a wide range in what each child knew before the unit. 'H' knew nearly two thirds of all the items while 'A' knew less than one quarter.

Second, there appears to be little relationship between what was known, what was learned, and what remained still unknown at the time of the third testing. There was a slight tendency for those who knew most to have learned least, but there were clear exceptions. Both 'D' and 'A' began with low scores. 'A' learned a lot (35% of items) and had a low percentage of items which were not learned (14%). On the other hand, 'D' learned relatively little (24%) and had a high percentage of items which were not learned during the unit (28%).

Both 'S' and 'K' seem to have learned the most from the unit (39% and 37%), but for 'S' most of this learning appears to have been temporary (25% was long term) while for 'K' most appears to have been long term (31%).

2.2 How Much Was Known and How Much was Learned?

In addition to exploring individual differences in the pattern of children's learning during the unit, this method of analyzing answer patterns provides the basis for identifying how each segment of the content was learned during the unit of instruction. In Table 8, the frequency with which each pattern of answers occurred for each test item has been tabulated. For example, there were 11 items which were answered correctly on all three

testing occasions by five or six of the children ('Items already known by 5 or 6 children'). There were a further 10 items which were answered correctly on all three testing occasions by four children, and so on.

Five items have not been included in Table 8 because the children's patterns of answering them were dispersed across several different answer-pattern categories.

The data in Table 8 suggests that there were 22% of the items known by almost all children before the teaching began. A further 20% were known by two thirds of the children. Thus the figure presented earlier (45% of items were known before teaching) misrepresents the situation if it is interpreted to mean that 45% of the content was known by all children before teaching. Only about half of that percentage was known by all children.

The data in Table 8 also indicates that only 8% of the items were learned by all children and only another 10% were learned by two thirds of the children. This compares with the figure of 32% from the data in Table 4. The reason for the low percentages for items learned in Table 8 is because the children are not all learning the same things. Their learning tends to be dispersed over different items.

However, there is reason to believe that all of the above figures may misrepresent the teachers' effectiveness in stimulating learning in the classroom. For example, an item might be known by 50% of the class before instruction. The teacher might teach the relevant knowledge very effectively so that all the children could answer the item after instruction. The data would show that 50% of the children had learned the answer during instruction. Another item might be known by none of the children before instruction. The teacher might teach the relevant knowledge relatively poorly so that half the children could answer the item and half (perhaps through misunderstanding or confusion) would get the answer wrong on the test. In this case the teaching would be less effective but the data would show the

TABLE 8

FREQUENCIES OF DIFFERENT ITEM ANSWER PATTERNS

	Number of items	Percent of items
1. Items already known (Category A)		
by five or six children	11	22
by four children	10	20
by three children	6*	12
2. Items learned in class (Categories D + E)		
by five or six children	4	8
by four children	5	10
by three children	7**	14
3. Items not learned (Categories F + G)		
by five or six children	1	2
by four children	2	4
by three children	4***	8

* Includes three items which were also learned by three children

** Includes three items which were already known by three children, and one further item which was not learned by three children.

*** Includes one item which was also learned by three children.

same pattern: 50% had learned the item during instruction.

If effective teaching means bringing all children to the level of answering all test items correctly, then any measure of teaching effectiveness needs to take into account both prior knowledge and change during instruction, and not measure them separately. An alternative method of classifying children's item answering patterns which attempts to do this has been used in organizing the cata in Table 9.

The first category (1. KNOWN) includes those items which were already known by five or six children (1.1 Known fully) and those items which were already known by four children and not ever learned by the other two (1.2).

The second category includes those items which were answered correctly by 5 or 6 children either because they all learned them during instruction or because all those who didn't already know them, learned them during instruction. This category has been labelled 'effectively learned' because the net effect is that all children knew the items by the second testing.

The third category includes those items which were learned in class by two or three children but were also answered incorrectly after instruction by two or more children. These items have been labelled 'partly learned' because while they have been learned by some children, there were still a significant number who never learned them.

The final category includes those items which were not learned by any children and were not already known by more than two children.

The data in Table 8 suggest that just over one third (37%) of the items can be identified as effectively taught in the sense that they were not already known by more than four of the six children before the instruction began, but were known by 80% after the instructional unit was completed. Only a small proportion of these were actually learned by all the pupils during the unit.

A further 20% of the items were taught less effectively and 10% were

TABLE 9

FREQUENCY OF ITEMS CLASSIFIED BY LEARNING EFFECTIVENESS

	Number of items	Percent
1. KNOWN		
1.1 Known fully (80%+)	11	
1.2 Known (67%) + Learned (<20%)	6	
Total Known	17	33.3
2. EFFECTIVELY LEARNED (80% or more correct)		
2.1 Known (50-67%) + Learned (33-50%)	10	
2.2 Known (17-33%) + Learned (50-67%)	5	
2.3 Learned by all (80%+)	4	
Total Effectively Learned	19	37.3
3. PARTLY LEARNED (67% or less correct)		
3.1 Learned (50%) + Not learned (17-50%)	4	
3.2 Learned (33%) + Not learned (50-67%)	3	
3.3 Learned (33%) + Not learned (0-33%)	3	
Total Partly Learned	10	19.6
4. NOT LEARNED		
Learned (<20%) + Known (0-33%)	5	9.8

either not taught or were not taught in a way which had any effect.

2.3 Summary and Comment

Analysis of the item answering patterns of the six children who were interviewed in this study, indicated that there were about 20% of the items that all the children knew before the instructional unit began. During the course of the instructional unit 37% of the items were taught effectively and a further 20% were taught less effectively. Thus the teacher had a significant impact on 57% of the items. The remainder were either not known beforehand (or were partly known) and were learned during the instructional unit by no more than one out of the six children.

This is quite a different picture from the one that would have been obtained from an analysis of total scores. The average total score on the pretest was 51.9% of items correct. The average total score on the immediate post-test was 79.7%. This suggests a learning gain of 27.8%. (See Table 10) If the item answering analysis procedures used in this paper have any validity, then they indicate that traditional analysis based on average total scores over-estimates prior knowledge and under-estimates the effectiveness of learning during instruction.

The difference is due to the fact that the analysis suggested in this paper is based on item performance and not on the total scores. It also takes into account the possibility that some items (content) may be effectively taught but are only learned by a small proportion of the children because they are already reasonably well known beforehand.

One further point needs to be made about this method of answer pattern analysis. Because each item is classified separately, it is possible to identify from this answer pattern analysis exactly what parts of the instruction have been most effective and which parts have been least effective. This in fact, was the original purpose for developing this method of

TABLE 10

TOTAL TEST SCORES FOR EACH CHILD EXPRESSED AS A PERCENTAGE OF TOTAL SCORE (51).

	Child's Name:						
	H.	G.	S.	K.	D.	A.	Average
First Testing	67	65	49	51	41	39	51.9
Second Testing	84	86	88	84	65	71	79.7
Third Testing	84	84	75	82	76	71	78.8
Immediate Gain (Second-First)	18	22	39	33	24	31	27.8
Long-term Gain (Third-First)	18	20	25	31	35	31	26.8
Forgetting (Third-Second)	0	-2	-14	-2	12	0	-1.0

analysis.

For example, for the seven week unit on conservation taught to the children in this investigation there were nine items in the test which were known by no more than two children before the unit, but were known by all of them after the unit was taught. The content of these nine items can be related back to the instructional activities which were occurring when that content was taught. Three of these nine items related to the 'hydrological cycle'. The teacher's diagram of that 'cycle' and the instructional activities that were related to it, had a significant impact on the children's memory (revealed in the interviews) and on their learning (revealed in test item performance).

Two or three other instructional activities (such as the sand and vacuum cleaner demonstration (see p.11 above) accounted for most of the 'effectively learned' items.

TABLE 11

RELATIONSHIP OF INTERVIEW RESPONSES TO CORRECT ANSWERING ON DELAYED POST TEST

Type of Interview Response:	Percentage of items answered correctly
Known from other sources	90
Known from other school experiences	89
Deduction from other knowledge	74
Deduction from unit learning	70
Learned in unit from visual material	86
Learned in unit from activities	90
Learned from discussion or reading	82
Learned from unit and also known	95
Guessed	36

TABLE 12

INDIVIDUAL DIFFERENCES IN THE RELATIONSHIP BETWEEN INTERVIEW RESPONSES AND CORRECT ANSWERING ON THE POST-TEST

	Percentage of items answered correctly Child's name:						
	H.	G.	S.	K.	D.	A.	All Children
KNOWN: from other sources and from other classes	91	100	80	92	100	92	90
DEDUCTION: from other knowledge	83	73	64	82	79	60	74
LEARNED: from unit, all types combined	88	96	86	93	72	68	84
GUESSED:	25				80	43	36

CHAPTER THREE

RELATIONSHIP OF INTERVIEW RESPONSES TO TEST PERFORMANCE

It is now possible, using the analysis of test performance developed in the previous section, to examine the relationship between what children said in the interviews and how they actually performed on the test items. Before doing so, however, it will be useful to look at the simpler relationship between their interview responses and the correctness of their answers on the third test (the test on which the interview was based). Data relevant to this relationship is contained in Tables 11 and 12.

3.1 Interview responses and correctness of test answers

The data in Table 11 suggests that when children reported that they worked the answer out for themselves (deduction from unit learning or other knowledge) they were more likely to get the wrong answer than when they reported that their answer was based directly on what they knew (70-74% vs. 89-90%). This is what might be expected if the children's interview responses accurately reflected the difference between their knowing the answer and not knowing it but trying to work it out.

Table 11 also shows a difference between the correctness of answers based on knowledge obtained elsewhere and the correctness of answers based on knowledge recalled from the instructional unit. On average the percentage of items answered correctly was six per cent lower when the child reported memory of the instructional unit as the basis for giving the answer than when the child said she/he already knew the answer. However, when the performance of individual children is taken into account (see Table 12) it is apparent that only two of the children showed this difference.

It can be seen from Table 12 that the four children with the highest test scores (H., G., S. and K.) were just as likely to be correct with answers

based on memory for the instructional unit as they were with answers based on knowledge from other sources. However, the two children with the lowest test scores (D. and A.) were more likely to be wrong when their answers were based on their memory of the instructional unit. A further feature of the performance of these two children was their luck with guessing. They both reported guessing more often than the other children (two or three times as often) and their guesses were more likely to be correct. One possible explanation for these differences is that these two children were simply less able to explain their answers than the other children. Hence some of the occasions on which their answers were both correct and based on an accurate memory for what they had learned, they described as guesses because they were unable to bring to mind, or articulate, the reasons behind their answers.* If this is so, then the real probability of uninformed guessing may be as low as 4%, not the 7% reported in Table 2.

3.2 Interview Responses and the Pattern of Item Answers

Table 13 depicts the relationship between the children's interview responses and their patterns of actual test item answers. The first column in Table 13 gives the distribution of children's interview responses for those items which were already known before the instruction began (i.e., correct on both pretest and posttest). The second column gives the distribution of all interview responses to the items which were learned effectively, and so on. Definitions of the items referred to in each column are contained in Table 9.

The data in Table 13 indicate that the relationship between what students

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* For example, when questioned on one item, D. stated that she had "guessed" the answer. When the interviewer accepted her response with "Fine, beaut!', D. hastened to add: "But I think I learned that before, but I can't remember, so I guessed".

TABLE 13

RELATIONSHIP OF INTERVIEW RESPONSES TO PATTERNS OF ITEM ANSWERS

(Percent of interview responses for each item answer pattern)

Type of interview response	Pattern of item answers: Known	Learned Effectively	Learned Partly	Not Learned
KNOWN: from other sources	23	7	8	17
KNOWN: from other school experience	13	2	3	3
DEDUCTION: from other knowledge	23	24	33	33
DEDUCTION: from learning in unit	5	1	7	
LEARNED: in unit from visual materials		16	5	
LEARNED: in unit from activities	2	7		
LEARNED: from discussion or reading	22	31	20	17
LEARNED and KNOWN	10	4	5	
GUESSED 2	6	7	27	
OTHER	2	3	10	3
Total number of responses	102	120	60	30

say about their item answering and the pattern of their actual performance is not a simple one. Some consistency in the relationship is apparent, but there is also some significant inconsistency. For example, for the items which were 'learned effectively' most of the responses indicate that the children thought they learned the answer during the conservation unit (59%) or they deduced the answer from gneeral knowledge (24%). Relatively few said they already knew the answers or guessed them. A similar pattern holds for items which were 'partly learned'.

However, items which were 'known' by most children produced a less consistent pattern of interview responses. A significant number (29%) who knew these items before the conservation unit, reported having learned the information during the unit.

If the simple assumption is made that all items answered correctly before the conservation unit should have produced 'known' responses during the interview, and that all items answered correctly after the conservation unit, but not before, should have produced 'deduction' or 'learned' responses in the interview, then between 30% and 40% of the children's interview responses were inappropriate or invalid.

There is, however, a problem with making this interpretation with Table 13. Some of the items in the 'learned effectively' column were already known by some of the children. (See definition in Table 9). Similarly the items in each of the other columns are classified by general pattern, and do not reflect individual children's performance patterns.

A more precise picture of the relationship between interview response and item answer pattern can be obtained by using the item answer patterns listed in Figure 3 for each child individually. The results of this analysis are presented in Table 14. As it turns out the pattern in Table 14 is similar to the pattern evident in Table 13. If a child's test answers indicated that he learned the information during the conservation unit and

TABLE 14

RELATIONSHIP OF ITEM ANSWER PATTERNS TO INTERVIEW RESPONSES

(Number of interview responses)

Type of Interview Response	Pattern of item answers: Known	Learned Long-term	Learned Short-term	Learned Later	Never Learned
KNOWN: from other sources	24	4	1	1	2
KNOWN: from other school experience	11	6			1
DEDUCTION: from unspecified general knowledge	19	18	6	3	8
DEDUCTION: from identified other sources	8	3	3	3	1
DEDUCTION: from learning in unit	5	2	1		1
LEARNED: from visual materials in unit	5	14	3		
LEARNED: from activities in unit	7	1		1	1
LEARNED: from discussion or reading in unit	35	17	4	7	5
LEARNED and KNOWN	14	3	1		1
GUESSED	1	2	7	3	5
OTHER	6	2			1

still remembered it one year later (Learned: long term) then there was about a 51% chance that she/he would have identified the conservation unit as the source of the knowledge in the interview. There was an 18% chance that other sources would be identified by the child as the source of knowledge and about a 25% chance that the child would claim to have worked the answer out on the basis of general knowledge.

The pattern for the items which were 'learned: short term' was much the same except for a significant increase in the number reported to have been 'guessed'.

When test items were known before the conservation unit, the children reported learning the information during the conservation unit 39% of the time. They reported obtaining the information from elsewhere for 42% of the items and working the answer out from general knowledge for 14% of the items. Table 15 contains a summary of this information.

3.3 Summary of Relationships between Interview Responses and Item Answering Patterns.

When children reported that they knew the answer to a question, or that they learned it during the conservation unit, there was about a 90% chance that they got the answer correct. However, when they reported that they worked the answer out from related knowledge, their chances of getting it correct were lower (74%). This suggests that the children were reasonably accurate in knowing when they 'knew' and in distinguishing knowing an answer from having to work it out or guess it.

However, there were marked individual differences indicating that some children were less accurate in remembering what they learned and possibly less able to give reasons for answers which they did have a good basis for answering.

The relationship between item answering patterns and interview responses

TABLE 15

RELATIONSHIP OF ITEM ANSWER PATTERNS TO
INTERVIEW RESPONSES : PERCENTAGES CALCULATED FROM TABLE 12

	Pattern of item answers:		
	Known	Learned (Long & short term)	Not learned (later & never)
KNOWN and DEDUCED: (from other sources)	42	18	18
DEDUCED: (from general knowledge)	14	25	25
LEARNED and DEDUCED: (from conservation unit)	39	47	36

was not simple. Children who knew item answers before the conservation unit frequently said they learned the information during the unit, and item answers that were learned during the conservation unit were frequently attributed to previous knowledge.

CHAPTER FOUR

INTERPRETING THE RELATIONSHIP BETWEEN INTERVIEW RESPONSES AND TEST ANSWERING PATTERNS

The simplest interpretation of the data contained in Tables 14 and 15 is that the children's interview responses are of little value because the children appear to have a limited capacity to report accurately the sources of the knowledge they use in answering achievement test items. In about 40% of the responses reported in Tables 14 and 15 there is an apparent contradiction between the children's interview responses and the pattern of their test item answers.

Such an interpretation depends, however, on the assumption that the forgetting, or lack of awareness, which produces inappropriate interview responses is a random or meaningless process that obscures rather than illuminates the nature of children's learning in the classroom. It is possible to make the opposite assumption that not only are the children's interview responses reasonably accurate and valid reports of their own cognitive processes or states, but that the apparent discrepancies between the interview responses and the item answer patterns are themselves further valuable evidence about the children's learning and memory processes.

There are two reasons why this second assumption is worth making. First, there is independent evidence on the validity of the children's interview responses which tends to support the view that the children do have reasonably accurate perceptions of their own memory processes. Second, making this assumption opens the way to a further analysis of children's learning and memory processes in which the apparent discrepancies between interview responses and test item answers are themselves the basic data. If this further analysis provides a coherent and useful addition to the picture of learning and memory produced by the interview responses, then the

assumption may be defended on the grounds of utility as well as validity.

4.1 The Validity of the Interview Responses

There are three types of evidence about the validity of the interview responses which are of increasing logical robustness.

First there is evidence of the "maximum capacity" of children's reported recall of class instruction and other experiences as sources of the knowledge used in answering test items. As some of the sample protocols reported in Chapter 1 (pp 7-14) and in Appendix A indicate, the children were capable of detailed and accurate recall of classroom activities. It is clear that recalling as much as one year later the circumstances surrounding the acquisition of specific knowledge is a task which children of this age are capable of.

Second, there is evidence that the children are aware of the distinction between 'knowing' an answer, and working it out or deducing it from other related information. While it is possible for children to 'know' the wrong answer and to answer a question wrongly on the basis of a genuinely held wrong belief, it is more likely that 'knowing' an answer directly will produce a correct answer than not knowing the answer but attempting to work it out from other related knowledge. The evidence contained in Tables 11 and 12 supports the conclusion that the children were aware of the difference between the occasions when they 'knew' the answer and the occasions when they 'deduced' it from other information.

Third, there is evidence of the match between children's recall of their learning experiences and the actual nature of the original classroom events. Here, the evidence needs to be treated with some selectivity. It is to be expected that children's memories of the original events will fade and distort according to normal forgetting processes over a period of time. That children do not recall all experiences with accuracy is to be expected. However, a

critical test of the validity of children's recall reports occurs when they are invited to recall events which did not occur. Fortuitously, there were three such situations in the present project. There were three items on the post-test which dealt with information which was not taught. The items were written to match the planned objectives of the teachers, and in general, the teachers kept very closely to their objectives. However, for three items, the planned material was not touched on during the unit.

During the interview, the children were asked the same kinds of questions for each of the items on the test. A relatively strong expectation must have been established that all items dealt with something that was taught or discussed during the instructional unit. Consequently, if the children were creating answers to meet perceived expectations, or were reporting 'imagined' rather than 'real' memories, they could well have responded to these three items as they responded to all the others.

The classification of their interview responses to these three items has been reported in Table 16. Two of the items (No. E16 and No. P5) were deduced by about half of the children and guessed or not answered by the remainder. The third item (No. End15) was guessed by all six of the children. On no occasion did any of the children report that they learned the item during the conservation unit. On one occasion, one of the children reported that he had deduced the answer from clues in the wording of the question. When pressed by the interviewer to recall if the topic had been discussed in class he replied:

> "Um, now that you mention it, yes. Um, I think so. Mr A, Mr M, no Mr H said something to us about that ..."

This was the only case of a child evidently responding to the demand of the interviewer's question, and even then, did not provide enough recall to be classified as anything other than 'DEDUCED: from general knowledge' on the basis of the child's earlier responses to the item.

This third type of evidence provides the strongest support for the

TABLE 16

STUDENT INTERVIEW RESPONSES TO THREE ITEMS NOT TAUGHT DURING INSTRUCTION

Interview Response:	Frequency of Response: Item: E16	P5	End 15	Total
3. DEDUCTION: from general knowledge:	4			4
4. DEDUCTION: from other knowledge:		3		3
6. GUESSED:	1	2	6	9
14. ITEM NOT ANSWERED ON TEST:	1	1		2

validity of the children's interview responses. Clearly there can be no certainty in making the claim that the children were responding genuinely on the basis of their actual awareness of their own memories and cognitive processes, but the three types of evidence taken together provide reasonable grounds for believing that they could and normally did.

4.2 Types of Discrepancies Between Interview Responses and Item Answer Patterns

Given that children's interview responses can be treated as valid representation of their awareness of their own memories and cognitive processes, it is now necessary to explain why some of the children's interview responses appear to contradict the evidence available from their item answer patterns. Table 17 contains a listing of the different types of discrepancies which are in need of explanation, and the frequencies with which they occurred. In each block of Table 17 a test answer pattern, or group of test answer patterns, is identified in the left hand column. The interview responses which appear to be incompatible with that test answer pattern are listed in the middle column. The frequencies are listed on the right.

The most common types of discrepancies are those in which the child got the item correct on all three tests (Known before testing) and reported in the interview that the information was learned from discussion or reading during the conservation unit (N = 36). The second most common are items in which the child got the answer wrong on the pretest and got it correct on the immediate post-test (Taught: long term and short term) but reported in the interview that the answer was worked out from general knowledge (N = 24).

The total number of all apparently discrepant interview responses was 124 which makes up 40.5% of all interview responses.

4.3 Memory Processes Apparent in Discrepant Interview Responses

Each of the apparently discrepant interview responses listed in Table 17

TABLE 17

TYPES OF APPARENTLY DISCREPANT INTERVIEW RESPONSES

Test Answer Pattern:	Interview Responses:	Frequency
A. Known before teaching	5. DEDUCTION from learning unit	5
	7. LEARNED in unit from visual materials	5
	8. LEARNED in unit from activities	7
	9. LEARNED from discussion & reading	36
D. Taught: long term E. Taught: short term F. Not taught: learned later G. Not taught: never learned	1. KNOWN: from other sources	9
	2. KNOWN: from other school experience	7
D. Taught: long term E. Taught: short term	3. DEDUCTION from general knowledge	24
D. Taught: long term E. Taught: short term F. Not taught: learned later G. Not taught: never learned	4. DEDUCTION from other sources	12
F. Not taught: learned later	5. DEDUCTION from learning unit	2
G. Not taught: never learned	7. LEARNED in unit from visual materials	2
B. Known and forgotten	8. LEARNED in unit from activities	9
C. Known with teaching error	9. LEARNED from discussion & reading	5
	10. LEARNED and KNOWN	1
	TOTAL	124

was examined in detail to look for clues to the possible reasons for the discrepancies. In many cases the problem arose because there were possibly two sources of information for answering an item. For example, the child might have known the relevant information before the instruction took place and have remembered it being discussed during instruction on the unit. The child might then judge that the discussion during the unit was more important, or made a significant difference to her/his understanding of the content. Thus, the child would mention the class discussion first in the interview and might or might not go on to mention previous knowledge. Occasionally this dual source of knowledge was made explicit:

> Pupil: Well, I knew that, um, when you go ... well, the hills were eroding away because the trees and native bush were being cut down by man. Then Mr H, um, brought it out more clearly, so we knew.

Sometimes evidence of this dual source of knowledge depended on the interviewer being alert to the possibility and asking appropriate follow up questions.

> Interviewer: Had you known about that beforehand?
>
> Pupil: Yes, just a little bit.
>
> Interviewer: But you learned it a bit more?
>
> Pupil: Yeah.
>
> Interviewer: Yeah?
>
> Pupil: I got more information.

It was difficult on all occasions to be sure that all the child's sources of knowledge for a particular item had been fully explored, especially when the child's description of specific class activities had been long and detailed. The frequency with which this occurred is discussed later (pp 68-69, Table 18).

As each of the interview responses was examined, a picture began to emerge of several memory or cognitive processes which could account for most of the apparently discrepant interview responses. A brief description of

each of these processes is provided in Figure 4. A more detailed description of each process with examples of the interview responses that exhibit them, is contained in Appendix C.

In brief, the evidence seems to indicate that there are three major memory processes, and two types of misunderstandings or confusions which account for almost all the apparently discrepant interview responses (omitting those where the right interview questions were not asked). The three major memory processes were:

1. Retroactive Effects. In this case it seems that subsequent learning or experience has overlaid and obscured previous learning. For example, the child may remember discussing a topic during the conservation unit. This memory may obscure the fact that the child already knew the relevant information before the conservation unit. When asked the child recalls the discussion in the unit and seems unaware that she/he knew anything about the topic before that discussion.

2. Proactive Effects. In this case there is a piece of information which interferes with what was learned during the conservation unit. In most cases this intruding information was a widely accepted belief that ran counter to the information being taught in the unit. The child recalled the intruding information as the information which was taught during the unit and appeared unaware of what was actually taught.

3. Integration Effects. In this case the learning which took place during the unit has apparently been integrated into the child's general knowledge of the world, of the meanings of words, and of general cognitive understanding. The child appears to have no recollection of when the relevant information might have been learned and either declares that she/he always knew it or couldn't remember when or how it was learned.

4. Misunderstandings and Confusions. In addition there appeared to be two types of misunderstandings and confusions which accounted for the remainder

FIGURE 4

MEMORY PROCESSES APPARENT IN DISCREPANT RELATIONSHIPS BETWEEN INTERVIEW RESPONSES AND TEST ANSWER PATTERNS

1. RETROACTIVE EFFECTS Subsequent learning or experience appears to have overlaid earlier knowledge so that the student is only aware of the later experience.

   1.1 Other school experiences with the same or other teachers on the same or related topics are cited by the student as the source of information.

   1.2 Instruction obscures previous knowledge. Memory for discussion or activity in the conservation unit overlays what was already known so that the student is no longer aware of what was known before instruction.

   1.3 Instruction dominates previous knowledge. The student recalls discussion or activity in the conservation unit, and is unsure if information was known before the unit, or claims it was only partly or incorrectly known.

2. PROACTIVE EFFECTS Previous knowledge, or knowledge acquired elsewhere (usually commonly accepted beliefs) intrudes on what was learned during the conservation unit so that the student claims that this other knowledge was what was learned during the conservation unit.

   2.1 Previous knowledge re-emerges. The intruding information reappears at the time of the third test creating a "Taught: short term' test answer pattern.

   2.2 Previous knowledge is dominant. The intruding information appears to have been used in answering the item on all three tests. The student believes she/he has learned the information in the unit, or acquired it from other sources, but has never got the item correct.

3. MISUNDERSTANDINGS AND CONFUSIONS There is a clear memory for the class discussion or activities but the precise nature of the information, definition or distinction being taught was misunderstood, or became confused with time.

Continued over page

FIGURE 4 continued

4. INTEGRATION EFFECTS The student appears to believe that she/he always knew the information, or had worked it out from general knowledge, when the test evidence indicates that it was not known before the instructional unit. The student seems to have lost any memory of having learned it.

4.1 Always knew the answer. Student claims to have always known the answer when test answer pattern indicates it was learned during the conservation unit.

4.2 Deduced the answer. Student claims to have deduced the answer from general knowledge and denies that anything relevant was learned during the unit.

4.3 Partial claim to have deduced the answer. Student recalls that the information was discussed in class but asserts that the answer was worked out independently.

5. MISTAKEN RESPONSE Both the interview response and the student's performance on the third test indicate that the student clearly knows and understands the answer so that there is a strong presumption that the incorrect answer on the second and/or third test was accidental

of the discrepant responses. The first type were those responses in which it was evident that the child had misunderstood or mistaken the nature of the information being taught during the unit. The child was able to recall the instructional activity and what was discussed but got the answer wrong on the test. Clues in the interview suggested that the child had never understood or had misunderstood the particular distinction or definition being taught.

The second type were those responses in which the child clearly knew the right answer in the interview but the test item had not been answered correctly. Careful probing by the interviewer indicated that the child could give good reasons for the answer and seemed to have no doubts or misunderstandings. The only reasonable explanation seemed to be that the child had got the answer wrong on the test by accident or oversight.

4.4 Classification of the Discrepant Interview Responses

Evidence from the interview protocol and from the pattern of test item answers was used to assign each discrepant interview response to one of the types of memory processes listed in Figure 4. For example, if a child stated in the interview that the information used in answering an item was learned in a more recent school experience (#2 Knowledge from other school experiences), but the child's pattern of answers on that item indicated that it was learned during the conservation unit (D. TAUGHT: long term), then it was assumed that the child's more recent school experience had overlaid and obscured the earlier experience during the conservation unit, and the response was classified as:

"1. RETROACTIVE EFFECTS, 1.1 Other school experiences" (See Figure 4).

It should be noted that this classification was based on the relationship between what the child said in the interview and the pattern of answers on the three tests. The classification of interview responses did not involve making

inferences about memory processes. If a child was asked if she/he recalled learning the information during the class unit, and the child said 'no', then this was taken to mean no more than that the child did not recall learning the information during the conservation unit. If this interview response occurred for an item which the child answered incorrectly before the conservation unit, and correctly immediately after the unit, the interview response would have been classified as:
"4. INTEGRATION EFFECTS, 4.1 Always knew answer" (See Figure 4). The interpretation that the process of integration had taken place is an interpretation based on study of all such responses and related evidence available from the protocols, and was not involved in the classification of specific responses.

The results of this classification of discrepant interview responses are contained in Table 18. Of the total of 124 responses, 48 or nearly 39% were not classifiable because the critical question had not been asked in the interview or the child's response had been ambiguous or unclear. Most of these (37) occurred in situations in which the child had given a description of learning the information during the conservation unit and the interviewer had accepted this description (often quite specific and elaborate) without probing further to find out if the child was aware of also knowing the material before learning about it in the instructional unit.

Among those responses for which all the necessary evidence was available, about one third showed evidence of retroactive effects, and another third showed evidence of integration effects. Among the latter, the most common situation was one in which the child reported working out the answer from general knowledge and denied, or could not recall, learning anything about that knowledge during the conservation unit. It may have been difficult for the children to conceive that they could both work the answer out for themselves, and also have learned how to do that, or have learned the

TABLE 18

FREQUENCY OF MEMORY PROCESSES SUGGESTED TO EXPLAIN DISCREPANT INTERVIEW RESPONSES

Explanatory Memory Process	Frequency	Percentage of those asked in interview
1. RETROACTIVE EFFECTS		
1.1 Other school experiences	6	
1.2 Instruction obscures previous knowledge	8	
1.3 Instruction dominates previous knowledge	9	
Total Retroactive effects	23	30.3
2. PROACTIVE EFFECTS		
2.1 Previous knowledge reemerges later	2	
2.2 Previous knowledge is dominant	5	
Total Proactive effects	7	9.2
3. MISUNDERSTANDINGS AND CONFUSIONS	10	13.2
4. INTEGRATION EFFECTS		
4.1 Always knew the answer	3	
4.2 Deduced the answer	20	
4.3 Partial claim to have deduced answer	5	
Total Integration Effects	28	36.8
5. MISTAKEN RESPONSES	8	10.5
6. NOT ASKED IN INTERVIEW		
6.1 Not asked if learned during instruction	11	
6.2 Not asked if known before instruction	37	

necessary background knowledge, at some specific point in the past.

4.5 Causes of Discrepant Responses

It was evident during the classification of the children's responses that a small number of items seemed to have produced an unusually large number of discrepant responses during the interviews. Of the total of 51 items used in this analysis, 10 items produced discrepant responses from four or more of the six children interviewed. Examination of these items suggested that different types of items were associated with the different memory processes.

(i) Three items dealing with the meanings of technical terms produced a higher than average number of integration effects. These words were:

slip (Correct answer in test: stones and earth have tumbled down a mountainside),

deforestation (Correct answer in test: cutting down all the trees in a forest), and

vegetation (Correct answer in test: all kinds of plants).

(ii) Two items for which there was an incorrect answer which is widely accepted as common knowledge, produced a higher than average number of proactive effects. One of these items dealt with animals which cause erosion. It is widely believed in New Zealand that rabbits are a major cause of erosion. In this item the correct answer was 'deer'. The second of these items dealt with forest regeneration. The commonly accepted, but incorrect answer, was that native forest in New Zealand will regenerate by itself.

(iii) Three items contained clues which the children used to work out the answer. What the children seemed unaware of was that they could not, or did not, identify those clues, and work out the answer

correctly, before the conservation unit. Hence their inability to identify the conservation unit as the source of their knowledge. For example, one item dealt with the name of an endangered species of bird in New Zealand. The children claimed they identified the correct name (Kokaka) by eliminating the other alternatives. Presumably before the instruction, they were not so familiar with the meaning of the concept of 'endangered bird' as to be able to employ the clues they did use to select the correct alternative.

Analysis of the items which produced higher than average numbers of discrepant responses suggested that children become less capable of identifying the sources of their knowledge when the relevant knowledge was used indirectly in a problem-solving process, or when there was significant misunderstanding or confusion between what was already known and what was learned.

CHAPTER FIVE

THE PRINCIPLES OF QUESTION ANSWERING AND LEARNING AND MEMORY PROCESSES

In the introduction to this report, we indicated that there were two major purposes guiding our analysis of the interview protocols. One was to examine students' perceptions of the way they answered achievement test questions and to relate the students' views of test answering to traditional methods of determining what achievement tests measure. The second purpose was to build up a picture of the memory structures and processes that seemed to underlie the students' interview protocols and test item performance patterns. These two purposes have not been kept distinct in our discussion because the analysis relevant to one has frequently informed the other, and vice versa.

It is now, however, necessary to draw the conclusions relevant to each purpose separately, and then make the relationship between them more explicit.

5.1 How do Students Answer Achievement Test Items?

The evidence obtained from this study indicated that, on a substantial proportion of the achievement test items the students did not agree on the cognitive processes involved in answering the questions. With a single contrast between 'knowing the answer directly from recall' and 'deducing the answer from related knowledge', the children disagreed substantially on 41% of the items. With a more specific analysis using distinctions between several processes and sources of knowledge (see Table 1), the students disagreed substantially on 62% of the items.

This amount of disagreement suggests that in the kind of achievement test used in this study about half of the items will have a specific

measurement function for most of the children, and the other half of the items will be measuring different things in different children.

The amount of functional ambiguity in achievement test items will be related to the design of the test and the conditions in which it is given. A test which is specifically designed to measure the outcomes of a particular unit of instruction will involve greater uniformity in the cognitive processes involved in answering each item than a test with a more remote or ambiguous relationship to the students' sources of test-relevant knowledge. In the latter case, there are many more ways in which the students could have acquired the relevant knowledge and skills, and consequently, many more forms which the knowledge and skills could take and ways in which they could be stored in memory.

Similarly, the time interval between learning and testing will also have an effect. Testing immediately after instruction precludes the possibility of changes in students' knowledge due to forgetting processes or the intrusion of other sources of knowledge. In this study, the interval of one year allowed for many individual differences in experience and cognitive history to influence the knowledge the children had available to answer the test.

The conclusion which emerges from this discussion is that what an achievement test measures is a function of the cognitive state of the individual being tested at the time the test is taken. If a student has the relevant knowledge in the form required to answer the test item directly, then the item will function as a 'factual recall' item. If the student does not have the relevant knowledge immediately available, then answering the item will require more complex cognitive processes and the use of indirectly relevant knowledge. What this implies is that knowing what an achievement test is measuring on a particular occasion requires knowing, from some other source, what a student knows, or can do, at the time the

test is being answered.

In this study, individual interviews were used as the independent source of information about the students' knowledge and question answering procedures. However, similar objections could be raised about the interviews. It is not entirely clear that the students did actually know what they said they knew, or really did work out the answers in the way they said they worked them out. It is tempting to conclude that a further independent source of information about the students' cognitive processes is needed to validate the answers they gave to the interview questions. However, we would still not know whether this further independent source of information was valid without yet another independent source of information about the students' minds, and so on in an infinite regression.

What lies behind this dilemma is the familiar impenetrability of psychological processes. Once it is claimed that it is not possible to tell what an achievement test is measuring without first finding out something about a student's underlying cognitive state, it is easy to be led into making the equally unsupportable claim that there is some true method of seeing clearly and directly inside a student's mind and finding out what is 'really' going on in there.

Unavoidably, psychological processes can only be described as part of a theory or theoretical explanation, and cannot be the object of direct observation. The traditional theoretical view has been that there is a direct one-to-one relationship between the apparent logic of the question contained in a test item and the psychological processes that are involved in answering the item. Test items measure the processes their wording appears to require. This is the theoretical view underlying the construction and use of Bloom's Taxonomy. If one could not tell, from an inspection of the wording of an item, where it fitted into the Taxonomy, there would not be any point in using the Taxonomy at all.

The interviews obtained in this study provide evidence which contradicts this theory. It is not possible to tell from the wording of standard achievement test items what cognitive processes or knowledge are involved in answering those items. This does not mean, however, that one should throw out achievement tests, and use interviews or some other procedure to assess what students know. Other procedures would be subject to similar problems of validation. What is needed is a better understanding of the way achievement test items are answered by students. This means a more adequate theoretical picture of the way memory and question answering processes interact so that we are better able to relate test performance to the cognitive state of the students, and consequently interpret that performance as a measure of the effects of instruction.

The next section is concerned with the development of a more adequate theoretical picture of such memory and question answering processes.

5.2 Memory Structure and Processes Evident in the Interview Protocols

Several sections of this report have focused on the memory processes and structures that were evident in the data being considered at the time. Section 1.2 discussed the general characteristics of the children's memories which seemed to emerge from the initial analysis of their interview protocols. Section 1.3 described a model of memory storage which summarized the dimensions of memory evident in the children's recall of instructional activities. Sections 1.4 and 2.1 contained discussions of individual differences in the interview responses and test item answering patterns of the children. Finally, Section 4.3 contained a description of a set of memory processes that explain the apparent discrepancies between the children's interview responses and their actual test performance.

The simplest way to summarize the information and discussion contained

in these sections is to present a brief outline of the structural properties and processes of memory that are implied by them. This is not intended to be a full and coherent theory so much as a listing of the characteristics of learning, memory and question answering processes that would need to be accounted for in a systematic theory of children's learning and memory for classroom instruction.

A. STRUCTURAL PROPERTIES OF MEMORY

A.1 Memory for instructional activities and experiences includes both:

(a) traces of the physical and temporal characteristics of the learning activities and their context (episodic memory), and

(b) the meanings, interpretations and immediate implications and associations of the content being taught (semantic memory).

See Figure 1 and examples on pp 9-10 (episodic memory) and p.7 (semantic memory).

A.2 Both contextual (episodic) and content (semantic) memory is organized into clusters of associated elements. Three forms of clustering are evident:

(a) clustering by temporal and spatial association of contextual elements,

(b) semantic clustering of content elements,

(c) clustering around an event or activity of both contextual and content elements.

The clusters referred to here may be similar to the schemata described by Rumelhart & Ortony (1977), Bransford (1979) and others.

Examples of these clusters can be seen in any of the extended descriptions of class activities and discussions cited in previous sections (cf. p12, pp 13-14, and Appendix A, pp 4, 6-9).

A.3 Some clusters of elements, or elements within clusters appear to

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be dominant in the sense that:

(a) they over-ride (or erase) any other logically conflicting elements (e.g., Appendix C, 2.2).

(b) they are preferred (get used more frequently) in processes involving deduction of an unknown answer or filling gaps in available knowledge.

Other things being equal, the more general or abstract elements tend to be dominant over the specific or concrete elements.

Note: The effect of this structural quality is that, with the passage of time, the content of memory becomes more abstract and logically coherent.

B. RECALL AND QUESTION ANSWERING PROCESSES

B.1 Question answering involves two processes:

(a) recall of the information needed to answer the question

(b) deduction of an answer from indirectly related information.

Both processes occur for most questions unless either is not possible because of the lack of availability in memory of relevant information. Where both can occur, the results of one may be used to check the correctness of the other. (e.g., p.12 above: confused recall).

B.2 The process of recall involves the eliciting of relevant clusters of content and associated contextual elements from memory, and either:

(a) the selection of an appropriate content element, or

(b) the use of an associated contextual element to trace an appropriate content element. (e.g., Appendix A, 5.2).

B.3 The process of deduction involves eliciting indirectly relevant clusters of content elements and using them in association with

a logical plan or template of a correct answer to deduce an appropriate answer. This process may involve making use of:

(a) Logical procedures such as identifying implications, making inferences, identifying similarities, and relating the specific to the general and vice-versa.

(b) Memory monitoring and search skills such as judging what is likely to be available in memory, using cues to identify relevant elements in memory, judging the usefulness of an element in deducing an answer. (e.g., Appendix A, 6.2, Appendix B).

(c) Information about tests, test taking procedures, and the 'rules of the test taking game'. (e.g., Appendix A, 4.2, 6.1).

C. MEMORY PROCESSES

C.1 The contents of memory are constantly being modified as a result of

(a) internal interaction between clusters and elements within clusters

(b) the external interaction resulting from the use of memory in ongoing intellectual activities

(c) the external interaction resulting from new learning experiences.

C.2 The internal interaction involves the absorption of less dominant elements by more dominant elements and the resolution of what seem to the child to be contradictions or conflicts between elements (see A.3 above) as well as the simple disappearance of some less well supported elements over time.

C.3 The external interaction involves:*

(a) Proactive effects in which older more dominant elements stored in memory absorb or alter the products of more recent learning

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* These are more fully described in Appendix C.

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experiences.

(b) Retroactive effects in which more recent dominant experiences absorb or alter the stored products of earlier learning experiences.

(c) Integration effects in which memory for past and present experiences merge into a unit or cluster of elements in which neither is distinguishable or dominant.

CHAPTER SIX

UNDERSTANDING WHAT MAKES INSTRUCTION EFFECTIVE

The outline of a theory of memory structure and processes set out in the previous chapter has interesting implications for assessing the effectiveness of instruction in developing students' knowledge.

6.1 Interaction of Contextual and Content Memory

The view presented above implies a significant interaction between contextual (episodic) and content (semantic) memory. In contrast with the traditional view that memory for contextual detail is short-lived and peripheral, this view implies that contextual memory may, on occasions, be stronger and more permanent than semantic memory. This may be because contextual memory remains isolated and hence distinct and readily identifiable, while semantic memory becomes integrated into a students' general knowledge and is not forgotten but is no longer separately identifiable. Thus, it may be only apparent that contextual memory of an instructional activity outlasts the relevant semantic memory.

Whatever the explanation, the importance of contextual memory is clear. An attempt has been made, in Table 19, to isolate the number of occasions in which the six students appeared to recall and make use of contextual memory for activities which occurred during the instructional unit. This has been done separately for the items which were learned long-term (incorrect on pretest, correct on both post-tests), the items which were learned short term (incorrect on pre-test, correct on immediate post-test but incorrect one year later) and the items which were not learned (incorrect on all three tests).

For all three types of items, approximately the same numbers (38%, 43%, 44%) were described by the students as having been always known or deduced from non-instructional or general knowledge (top row Table 19).

TABLE 19

PERCENTAGE OF DIFFERENT INTERVIEW RESPONSES TO ITEMS WHICH WERE LEARNED OR NOT LEARNED DURING INSTRUCTION

Interview Responses	Items which were: Learned Long Term	Learned Short Term	Not Known & Not Learned
KNOWN or DEDUCTION from all other sources	44	38	43
DEDUCTION from unit learning	3	4	4
LEARNED from discussion Non-specific	8	4	13
LEARNED and KNOWN	4	4	2
TOTAL Non Contextual	15	12	19
LEARNED in unit from visual and activities	21	12	4
LEARNED from discussion with specific detail	15	12	11
TOTAL with contextual memory	36	23	15
GUESSED	3	27	17
OTHER	3	-	6
TOTAL number of items	73	26	47

There were three types of interview responses in which the student claimed to have made use of information learned during the unit, but gave no specific (contextual) detail of the learning experience. These have been grouped together in Table 19 as 'DEDUCTION from unit learning' (5.0 in Figure 2) 'LEARNED from discussion, non specific' (9.0 in Figure 2) and 'LEARNED and KNOWN' (10. in Figure 2). Again, the total percentage of interview responses in these three categories is similar for the three types of items (15%, 12%, 19%).

There were several categories of interview responses in which memory for contextual detail was evident. These are described in Table 19 as 'LEARNED in unit from visual and activities' (7. and 8. in Figure 2) and 'LEARNED from discussion with specific detail' (9.1 and 9.2 in Figure 2). The total percentage of responses in these 'contextual' categories shows a distinct difference between items learned long term (36%) and items not known and not learned (15%). Items learned during the instruction but answered incorrectly one year later show an intermediate percentage of contextual recall (23%).

While this is clearly circumstantial evidence, it is consistent with the claim that memory for contextual detail plays a significant role in recall of information learned during instruction. The better the recall of contextual detail, the better the performance on items testing long-term recall.

6.2 The Parallel Use of Recall and Deduction Processes

There is some evidence from the interview protocols to suggest that 'recalling' and 'deducing' the answers to test items are not alternative processes but tend to work in parallel whenever this is possible. There are some occasions on which recall of the answer to a question is clear and immediate and any attempt to determine the answer by any other means seems superfluous. There are some other occasions on which it is clear to the

student that any attempt to recall the answer would be fruitless and some other means of working the answer out must be employed. However, there are many occasions, probably the majority, when both processes are possible and are made use of. In fact, the two processes become entangled with each other. When the answer does not immediately come to mind and some attempt must be made to search memory for it, the processes involved become increasingly similar to the processes of deduction as the search becomes more difficult and the information available less complete or adequate. Associations must be searched and evaluated, the probable form of the desired answer determined and so on. Although the interview protocols are only suggestive, it seems likely that several search and deduction procedures may take place simultaneiously producing results which can be used to validate or evaluate each other. An illustrative example has been reproduced in Appendix D. On another occasion a pupil described rejecting the result of his deduction in favour of an answer obtained from recall (see example on p.13).

It would seem to follow from this evidence that a more successful pupil is one who has acquired efficient skills for searching memory and deducing answers from other available knowledge, or whose memory is structured in such a way that these processes are facilitated. While the former is probably a product of instruction and test-taking experience over a long period of time, the latter should be a function of the way immediate instruction is structured. Exploring the kinds of memory search and answer deduction skills which students should learn to use is beyond the scope of this report. It might be noted, however, that if contextual memory has a significant role to play, then learning to use contextual evidence should be considered as well as learning to use knowledge stored in semantic memory.

6.3 Structure and Confusion in Memory

It is evident from the interview protocols, that what is stored in

memory can often be wrong. Mistakes are caused both by forgetting and by recalling incorrect information. The latter may be due to learning the wrong things at the time of instruction, or by distortions occurring with forgetting. The category: 'Misunderstandings and confusions' described and illustrated in Appendix C provides examples of this phenomenon. Earlier incorrect ideas may erase correct ideas learned during instruction. Contradictory or conflicting instructional experiences may be resolved in memory in favour of an incorrect alternative. The teacher is thus faced with the task of not only providing children with the correct information at the time of instruction, but helping them to understand and store that information in ways which will withstand the internal and external influences affecting its preservation through time. This is not to say that students must remember the original information in all its detail, but rather that what does remain, as forgetting takes place, should not be inconsistent with the original information and will not lead to incorrect deductions. Quite how this might be done requires a much better understanding than we now possess of the way memory changes with time. However, there are some indications from the interview protocols. Briefly these are:

1. <u>The importance of students' prior beliefs</u>. Where students have strongly held incorrect beliefs, or where the information being taught runs counter to beliefs held in the community which the student is likely to be exposed to, the teacher needs to ensure stronger support for the newly taught information.

2. <u>Non-arbitrary contextual experiences</u>. The physical and contextual qualities of instructional activities should relate in some non-arbitrary way to the information or semantic content of the activities. Presumably this means a constant interaction between the experience and the instructional meaning of that experience. For example, field trip experiences need to be closely and constantly linked into the instructional purposes of the field trip.

3. <u>The need for alternative pathways to the same information</u>. If students

normally use different processes in parallel in answering achievement test items, the facilitation of alternative ways of locating or deducing specific information is an effective way of facilitating this practice. Elaborating the reasons or evidence for information being taught seems an obvious way of creating the kind of network of logical associations which could be used for this purpose.

4. Detecting and clearing up misconceptions. It is almost too obvious to draw attention to the need for preventing student misunderstanding, but it might be noted here that, because of the dynamic nature of memory, one misunderstanding can, over time, have quite pervasive and unpredictable effects over a wide area of knowledge. Again, elaborating the reasons and evidence for information being taught would seem an effective way of counteracting this effect.

6.4 Summary Comment

In this report we have been concerned with how children answer items on an achievement test, how their answering processes relate to the nature of the items, and what information the children's account of these processes provides about learning and memory for instruction. In the last two chapters we have attempted to outline a theory of learning and memory processes which will describe more accurately what an achievement test might be measuring, and what conclusions can be drawn from the test about the effectiveness of instruction.

In the process of constructing this report, we have developed a new way of scoring achievement test results which provides more information about item answering patterns (Figure 3); we have developed a method of classifying the way students describe their item answering procedures (Figure 2); and a classification of memory processes implicit in the apparent contradictions that occurred between item answering patterns and

the children's interview responses (Figure 4). We have also discussed, briefly, individual differences in item answering and interview response patterns (Tables 2, 3, 4 & 5); the nature of the guessing that takes place (Tables 7 and 12); the analysis of item answering patterns to determine teaching effectiveness (Tables 8, 9 and 10); and the validity of the interview procedure in this kind of research (Section 4.1, Table 16).

The evidence on which this report has been based has been primarily the interview protocols and the achievement test results of six children. In traditional terms, this is a flimsy base on which to construct such an elaborate superstructure of ideas and theoretical claims. Clearly, what we do not know is how unique the data we obtained is to the special circumstances in which it was gathered. We cannot tell, and hence can make no substantial claim about how general the conclusions and interpretations might be. They are based on a small number of children, taken from one classroom, and on one set of achievement test items and one set of interviews.

In defense we can claim that we made every attempt to cross-validate all our interpretations within and between individual interview protocols and achievement test answers. What appeared in one child's interview answers was checked against other children's answers, and against the same child's answers at another point in the long interviews. Where appropriate, external evidence from our observations and recordings of the original instructional unit was also used.

We also made an attempt to keep our interpretations of data consistent with current research on memory and learning processes in children. Some references to this research are explicit, but often the reference was to general ideas and ways of viewing data for which no specific reference seemed appropriate. The reader familiar with recent work in cognitive psychology will probably have noted our considerable indebtedness to much of

the literature in this area.

Finally, however, all we can claim is a set of hypotheses about the nature of learning and memory processes in children which are relevant to the assessment and understanding of teaching effectiveness. These hypotheses need validation, both as to their generality and their usefulness in developing teaching effectiveness research.

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TYPES OF STUDENT RESPONSES

1. KNOWLEDGE FROM OTHER SOURCES

1.0 Source Not Identified

Student knows that information comes from somewhere other than class project, but cannot identify source.

Example (from interview on response to item dealing with the meaning of the word 'environment')

I: How did you know that, Ana?

S: Well, I just knew. I don't know ...

I: Did you know it before you ever studied conservation?

S: Yes.

1.1 Information From Other Sources

Student identifies the information as something he was told, read in a book, heard on TV, or acquired from some other non-school sources, as a piece of information.

1.11 General Sources

(Item on rabbits as a source of erosion)

S: I put rabbits because I've, um ... you always hear people talking about things like, um, rabbits are bad ...

1.12 Television

(Item on the presence of water below the ground)

S: Once on TV I saw thing about a volcano, and all the water under the ground forced all the mountain up, and that, um ...

1.13 Reading

(Item concerned with whether there will ever be no people left)

S: Lots of science books that I read about, out of the library, about the solar system ... there's always something about a prediction that one day the world will

blow up ... and that's probably just why I put that.

1.2 Out-of-School experiences

Student identified the information as something obtained from experiences or activities occurring outside school classrooms.

(Item about what happens when water freezes)

S: Sometimes when we go home, my brother, he gets little old pill bottles and he puts water in them and he puts them in the 'fridge and in the morning they all shatter and that ... just little ice balls.

2. KNOWLEDGE FROM OTHER SCHOOL EXPERIENCES

Student identified other lessons or other teachers as the source of the information.

(Item on the meaning of the term 'life-cycle')

I: Now you said that a life-cycle was the way an animal changes from a baby to an adult. Why did you choose that answer?

S: Because last year, in a different unit, um, Mr H told us about the life-cycle of a butterfly.

(Item on the meaning of the term 'introduced animal')

S: Like Captain Cook, I think, he introduced pigs ... I remember in the library doing that.

I: Do you remember Mr H talking about that at all?

S: No. I don't think I can. I remember because I was doing one (project) about pigs and Captain Cook, and I remembered that one, especially.

3. DEDUCTION FROM GENERAL KNOWLEDGE

The student doesn't appear to have known the answer, but indicates that it was worked out on the basis of what the student knew. The source of this knowledge is not identified and could well have been the class project.

(Item on the worst kinds of pollution in the countryside)

I: You chose old plastic bottles and chemicals. Why?

S: Well, ah, I reckon they pollute the air and that, and ... and Mr H did talk about that, um, then, and I can't remember what ones. I can remember ... I think he did say exactly what one was, um, worst, but I can't remember it.

I: Did you think rotting wood and leaves might be quite bad?

S: Oh, I think they're quite bad, but, um, I thought mostly plastic bottles and chemicals even though I didn't know, but that sort of popped up mostly in my mind.

I: Good. Were there any reasons why it would have popped up?

S: Well, plastic bottles and that, they've sort of got germs and they pollute the air, and that.

4. DEDUCTION FROM KNOWLEDGE FROM OTHER SOURCES

The student doesn't appear to have known the answer, but to have worked it out on the basis of knowledge or information obtained from other sources, or from clues given in the question itself.

4.1 Deduction From Knowledge Obtained From Other Sources

(Item about plants giving off oxygen and absorbing carbon dioxide)

S: I wasn't quite sure if it was the other way round. When you watch TV, well sometimes I watch Jacques Cousteau, and they have, I think, its oxygen tanks and that ... so he couldn't be breathing carbon dioxide ...

4.2 Deduction From Clues in the Question Itself

(Item about 'effluent' as a kind of water pollution)

S: Probably just because it sounded right. I didn't really know whether it was ... 'cause probably because the 'effluent' ... fluent sort of sounds like fluid, which is 'water' ... I just guessed that one.

5. DEDUCTION FROM INFORMATION LEARNED DURING CLASS PROJECT

5.1 Deduction from General or Vague Memory of Class Discussion or Activity

Student appears to have guessed or worked out the answer on the basis of memory for class discussion without being able to specify enough of what was said or done to indicate how the deduction was made.

(Item about how oil spillage poisons the food of fish)

I: Did you know that?

S: Ah, no.

I: Did you learn it from the unit?

S: Yes.

I: Do you remember Mr H talking about it?

S: Ah, not really. But I remember him saying about oil spills being bad for fish, and I just put "poisons their food" ...

5.2 Deduction from Recalled Class Discussion or Activity

Student appears to have worked out the answer from a specific memory of a class discussion or activity.

(Item about the need for flightless birds to find food at ground level)

S: We had to draw a picture of a Kiwi, and the person sitting next to me drew a Kiwi, and ... he drew the body about half the size of the piece of paper, and then really big legs. And I said, 'that doesn't look right', and then the next day went up and asked the teacher, and he said, 'that's not right, they're meant to have short legs'. So, seeing they have short legs, I thought, you know, they're going to have to have food near the ground to be able to reach it.

6. GUESSES AND DEDUCTIONS BASED ON IRRELEVANT CONSIDERATIONS

6.1 Calculation of Risks Involved in Guessing (Test Taking Reasons)

Student's reasons for answer relate to analysis of chance and gains to be made from guessing or giving any answer.

(Item asking to identify agents of erosion from a list given)

S: Oh, I didn't know whether to put it down, and I was going to put it down and then, well, I might as well not, because it's not right. And if it is right, well it doesn't really matter. I don't really mind, so I just sort of decided to put it not down - not to put it down.

6.2 Guesses Based on Lack of Understanding of Misunderstanding of Question

Student appears to have guessed or worked out the answer on the basis of a misunderstanding of the meaning of the question, or words in the question.

(Item about the limited amount of air around the earth)

I: You put 'the amount of air around our world could be described as finite'. How did you choose that one?

S: Um, oh, I don't actually know why I picked that one.

I: Do you know what finite means?

S: No. I get mixed up with finite and infinite. One's, um, never end, and one's got an ending.

I: Okay, You picked the one that has got an ending. Why did you pick that one?

S: Um, I don't know actually.

6.3 Guesses With No Explanation

Student indicates that the answer was guessed and no explanation is offered.

(Item on plants absorbing carbon dioxide)

I: What do plants take in from the air?

S: I don't know.

I: Did you just have a guess on that?

S: Yep.

7. LEARNED DURING CLASS PROJECT: VISUAL MEMORY

Student identifies a demonstration by the teacher, or chart, or picture as the source of the information used to answer the test item.

(Item on wind as a cause of erosion. Demonstrated in class by the teacher using a vacuum cleaner to blow air on to a pile of soil. The demonstration took place in a small room attached to the classroom known as the 'flea-pit')

I: What made you put down strong winds? What made you remember that?

S: Um, in the flea-pit, working with the vacuum cleaner.

(Item asking if noise can damage hearing)

S: I didn't know it until we were talking about it in the conservation unit thing, about people getting deafened by really loud noises, and we'd looked out the window ... and there was this man mowing the lawn, and this great big tractor. He had to be wearing ear-muffs, and that ...

8. LEARNED DURING CLASS PROJECT: MEMORY FOR ACTIVITY OR LEARNING CONTEXT

8.1 <u>Memory for Dramatic Activity or Actions</u>

Student recalls dramatic, mime, or role-play activity in which she participated, as the source of the information used in answering the test item.

(Item concerned with stones getting smoother and smaller as they get washed down rivers)

(a) S: Well, on the boulder one, the reason I gave that they become smoother and smaller, because I can remember ... when we were acting in the 'flea-pit' from becoming jagged rocks to smooth ones as we rolled down a stream ...

(b) S: We were in the flea-pit and, ah, we're all pretending we were rocks, and rolling around and that ... pretending we were banging into each other ...

I: And that's how you remember it?

S: Yeah.

8.2 Memory for Learning Context or Learning Activity

Student recalls some learning activity such as drawing a chart, writing a story, learning a spelling list, as the source of the information used in answering the test item.

(Item about the meaning of 'deforestation')

S: When we were in D Block we had it in a spelling list. We had to learn what it meant. I think that's when I learned that it meant was cutting down the trees and that.

(Item about the amount of water that is drinkable)

S: Because, once we did a chart ... and it had squares like a maths book, with all little squares on there ... there was a hundred of them ... and that's, there's still basically only about one per cent of water that's able to be, um, drunken ...

9. LEARNED DURING CLASS PROJECT: MEMORY FOR DISCUSSION, BEING TOLD, OR READING

9.0 Recalls Hearing Information But Not How or Where

Student seems fairly sure that the information was heard in class and not elsewhere, but is vague about when or how the discussion took place.

(Item about plants giving off oxygen and absorbing carbon dioxide)

I: How did you know? Did you work that out or did you remember someone saying something about it?

S: Oh, I remember some ... Mr H saying something about it, but I can't remember what.

(Item about hill run-off as the main source of water)

S: Um, I think I can remember Mr H saying about, um, oh ... I've got the picture in my mind, but I can't sort of say it ...

I: Tell me about the picture.

S: Um, something about, to do with roads and gutters, I think, or underneath roads ...

9.1 Recalls the General Nature of Discussion or Reading in Which Information Occurred

Student recalls the general nature of the discussion in which the information was heard, but cannot provide any specific details of what was said. Or recalls reading it in library or book in class.

(Item about the length of time it takes for native forest to regenerate)

S: I think we were talking about some native trees, and that they get put in a nursery when they're about 3 months old ... and that they take about two or three years, I think it was, to grow up.

(Item about the need for water by all living things)

S: Yeah, because I remembered Mr H telling us that. Not for some living things, but for all living things, have to have water.

I: You remembered that quite clearly, then?

S: Yes.

9.2 Recalls Specific Details of Class Discussion

Student recalls the class discussion in which the information was heard, and provides some specific detail of what was said or done.

(Item about the amount of water needed to produce one kilogram of meat)

S: We were talking about it and people were guessing. Mr H

asked us: 'How much do you think it would take to get one kilogram of meat?' or whatever it was ... some piece of meat ... and um, all the people were guessing about a bottle or a glass or something like that. Then he told us that it would be over 50 bottles or something ... about, around about there ...

I: And did you get it right when he asked you to guess, way back last year?

S: No. He had to tell us. I think he had to tell us. I didn't get it right. Someone else might have, I'm not sure.

(Item about native forests being destroyed by opossums)

I: Where did you learn that? How did you find that out?

S: That was last year. We were talking about endangered species and someone said, 'the opossum', and Mr H asked them why they thought it was. And they thought the same reason. And most people put their hands up ...

(Item about the meaning of erosion as 'wearing down something')

S: Oh, yes, well I remember he said, um, well, your elbow when you're writing, if you're getting it against the desk, and it starts to wear out and that. And rocks down a river, you know, they slowly wear out like that.

10. INTERACTION OF KNOWLEDGE LEARNED DURING CLASS PROJECT AND KNOWLEDGE FROM OTHER SOURCES

10.1 Information From Class Project And From Out-of-School Sources

Student identifies both the class project and an out-of-school experience as the source of the information used to answer the test item.

(Item about the disappearance of dinosaurs)

S: I was thinking about the things that we (the class) were talking about ... about endangered species and some of them

haven't got the ability to be able to change their sort of life-style to a different place ...

I: Did you see David Attenborough's programme (on TV) when he talked about that?

S: Yeah, that was good.

I: Did that help, do you think?

S: Yeah.

(Item about the meaning of the word 'extinct')

S: I can remember, um, I put 'extinct' because Mr H talked extinct birds and that. And, um, I learned it from there, and I learned that before, though ...

10.2 Information From Class Project And From Other School Experiences

Student identifies having learned the information during the class project, and at other times in school.

(Item about the hydrological cycle, and hill run-off as a source of water)

S: Mr H told us about that. And he did a wee diagram.

I: Did you do one too?

S: Yes, I think so ...

I: You remember that diagram very well, don't you?

S: And we did it again this year, too.

I: Did you? Who did you do it with this year?

S: Oh, we did it just for Mr A.

I: Yeah.

S: He just drawed it up on the blackboard because we were ...

11. UNINTENTIONAL OR CARELESS ERRORS

Student identifies his answer as an error which he didn't intend to make, or made because he wasn't thinking at the time.

(Item in which people are identified as the main cause of pollution)

I: You put pollution is mainly caused by storms.

S: Oh, I think I might have thought that was erosion sort of thing. Now I sort of really think about it properly, it was probably 'people'.

(Note: This item follows immediately after a sequence of items on erosion.)

(Item in which students are asked if it would matter if all elephants died out)

S: Well, I don't really know there, because I just sort of weren't really thinking. I just put down any answer that was to do with elephants, and that. I didn't really know. And Darcy was putting down that they couldn't make Tarzan movies without elephants, but I didn't think that was a very good answer, so I didn't put that down.

12. NO MEMORY FOR DOING ITEM ON TEST

Student is unable to recall anything about completing the item at all.

(Item about the causes of erosion)

I: You put down that erosion is caused by people, animals and weather and water. How did you know that?

S: I don't remember doing that one.

I: Don't you?

S: No.

13. INADEQUATE INFORMATION

13.1 Interviewer Fails To Ask Student

13.2 Student Gives No Answer, Or Answer Unintelligible

14. ITEM NOT ANSWERED ON TEST

Appendix B

NOTE ON PUPILS' AWARENESS OF MEMORY PROCESSES

There is empirical evidence to indicate that recall is increased significantly when appropriate cues are provided (cf Bransford, 1979, pp 56-58). Adults are usually aware of this phenomenon and describe occasions on which they are surprised at how much 'comes back to them' when their memory is triggered by the right situation or stimulus. Pupils at this level (9-10 years) also reported the same awareness, as is evident in the following example:

Interviewer: Do you feel like you remember quite a bit when I gave the test this morning?

Pupil: I remembered ... not that I remembered this morning, when I was writing down things, I remembered about a quarter of the things I remembered doing the test, and, um, it all started coming back to me. Started getting the questions, and I needed to remember all the things, and um, I just seemed to remember.

APPENDIX C

PROCESSES APPARENT IN DISCREPANT RELATIONSHIPS BETWEEN INTERVIEW RESPONSES AND TEST ANSWERS

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1. RETROACTIVE EFFECTS. The impression is given that experiences that have occurred after the original learning have become integrated with, or have overlaid the original learning so that the child identifies the later experience as the source of the knowledge.

   1.1 Other School Experiences. Although the information was discussed during the conservation unit, the same or similar information has been discussed at a later time by the same teacher or by other teachers. The child identifies this latter experience as the source of the information.

   Example: (item on evaporation as a source of water)

   I: Do you remember learning that during the unit?

   S: Yeah.

   I: Who taught ... ah ... How did you learn that?

   S: Oh, actually, we just did it in science a couple of days ... a couple of months ago, actually.

   Example: (item on meaning of 'native fauna')

   I: How did you know that?

   S: Because of the Carribean (unit) for social studies. I did flora and fauna.

   I: You didn't learn it during the conservation unit last year?

   S: It was this year.

   I: Good, O.K.

   1.2 Instruction Obscures Previous Knowledge. The child recalls the information as having been taught or discussed during the conservation unit. This memory appears to have overlaid and possibly obscured any memory for the fact that the information was known before the conservation unit. The child denies that it was known before:

   Example: (Item relating endangered species to native forests)

   Note: Child got this item correct on the pretest.

   S: Because there are hardly any native forests in New Zealand and if there are, they're mostly smaller, fairly small forests ... And, if there are hardly any of them, then the birds that really need the native forests would die ... start dying out.

   I: That's interesting. So you worked that one out again. You didn't remember, you just worked it out?

APPENDIX C (continued)

S: Um, well, when we were doing the .. um .. the little map of our own park, I think someone in the group suggested a Pukeko, or something ... and, um, they asked what we should put it in, and we, um, one of them went up and asked Mr H., and he, um, said that we could put in native forests because they'd need it ... (etc.)

Example: (Item on meaning of a 'slip')

(Note: Child got this item right on all three tests)

I: ... how did you know that?

S: I just remembered it.

I: Yeah, did you remember it ... did you know it before?

S: No.

I: That's something you learned?

S: Yeah.

I: Did Mr H ever talk about that ...

S: Yes.

I: Can you remember how he talked about a slip?

S: It's just like, um, there's a hill which has a lot of rain on it and the mud all falls away ... (etc.) ... he did it on the blackboard.

1.3 Instruction Dominates Previous Knowledge. The child recalls the information as having been taught or discussed during the conservation unit. The child is not sure whether it was known before instruction, or is aware that it was partly or not 'properly' known before the instruction. Hence the child tends to emphasize the unit as the source of the knowledge.

Example: (Item on the meaning of 'erosion')

I: How did you know about erosion? Before the conservation unit?

S: No ... My mum told me about that, you know, before. Because we were going through the hills and she said: 'Look how they had taken out the trees and all the earth had fallen down to the ground because of the rain ... erosion ...

I: Aha, And then what happened when you studied it with Mr H.?

S: I knew what it meant properly.

Example: (Item on plastic and chemicals as the worst kind of pollution)

S: Mr H, I think, he told us about that and all the pollution that was coming out of factories and going into rivers ... (etc.) ... chemicals are bad for your health and old plastic bottles sort of make the world look untidy.

I: Would you have known about that before you studied it?

S: Mm ... probably just a little bit. I'm not sure about that.

APPENDIX C (continued)

2. PROACTIVE EFFECTS. Previous knowledge, or knowledge acquired elsewhere and probably known before the unit appears to have intruded on what was learned during the conservation unit and changed it. The child claims that this prior knowledge (usually commonly accepted ideas) was learned during the conservation unit.

2.1 Previous Knowledge Re-emerges. The item was answered correctly after the unit but the previous beliefs reemerge so that the item was answered incorrectly on the third testing one year later.

Example: (Item on deer as a cause of tree damage in forests)

Note: This child answered this item correctly on the immediate post-test but incorrectly on the pretest and third test. The correct answer is deer, but rabbits are widely known in N.Z. as a cause of erosion.

I: Which of these animals has been a major cause of erosion in N.Z. forests?

S: I know. Rabbits.

I: How did you work that out? How did you know?

S: Oh, I ... Mum and me and my brother - we were out in the country and I heard shots and I said: 'What's that?' and she said: 'It's just those farmers shooting rabbits' and I asked her why and she ... because it keeps eating trees and stuff. I can't remember what she said but she said rabbits are bad.

I: Yeah, Did Mr H. talk about it?

S: He talked about deer, but I can't remember if he talked about rabbits.

I: Fine ...

2.2 Previous Information is Dominant. The item was never answered correctly because previously held beliefs remain dominant. However, the child attributes them to the teacher or the class discussion so that the child assumes that she/he has the right answer and learned it in class.

Example: (Item on the failure of native forest to regenerate)

Note: Children tend to agree with the commonly held belief that all trees will regenerate but do so slowly.

I: When a native forest is cut down, what happens?

S: Um ... it takes many years before the trees grow again.

I: How did you know that?

S: Um, I think Mr H. sort of told us, because native forest takes a long time to grow, and I think Mr H. told us about that.

I: Do you? Good. O.K.

Example: (Item on deer as a cause of tree damage in forests)

APPENDIX C (continued)

Note: This is the same item as the one used in 2.1 above. In this case the child got yhe item wrong on each test, believing her answer to be the correct one, as taught in class.

I: How did you know that?

S: Um, well my father told me a couple of years back that rabbits were a major cause of erosion in New Zealand ...

I: Yeah.

S: ... that there were lots of rabbits, but quite a lot have been killed off. Mr H. told us a wee bit about it, I suppose.

I: You're not sure about it?

S: Yeah, he just sort of talked a bit about the animals that were in ... in (inaudible) ...

3. MISUNDERSTANDINGS AND CONFUSIONS. In this case, the child believes that he/she learned it in class and can recall the occasions on which the information was acquired. However, the information appears to have been misunderstood or confused at the time of learning and the child's test answers indicate that it was never learned correctly, or became incorrect over time. This is most common with word meanings involving arbitrary distinctions, e.g., the meanings of flora and fauna or infinite and finite. The children remember the general meaning of the pair of words but not the precise meaning of each word.

Example: (item on the meaning of 'native fauna')

I: You put native plants up here. Tell me about your answer and how sure you are.

S: Because flora is animals and fauna is plants.

I: So you know that one's one and one's the other.

S: Yeah.

I: How did you learn about flora and fauna?

S: Oh, through teachers ... through Mr H and Mr K.

I: You've learned about it before you went to Mr H.?

S: Yeah, ah, just sort of, a bit.

I: Did you remember it coming up during the conservation unit?

S: Yes, sort of ...

Example: (item on the amount of water needed to produce one kilogram of meat).

S: I can remember Mr H. saying, I think, all the water in the (swimming) pool over there. Um, I don't know how many ... well, what's litres ... so I put, I think, I put 50 litres. I wasn't too sure what litres are ...

4. INTEGRATION EFFECTS. The child appears to believe that she/he always knew the information, or worked the answer out for herself/himself,

although the test results indicate that the child did not know the answer before the instruction. In both cases, the information appears to have become thoroughly integrated into previous knowledge.

4.1 Claims Always Knew Answer Child claims to have always known the answer, although the answer was wrong on the pretest. This occurred most often with meanings of words.

Example: (Item on the meaning of the word 'slip')

I: Did you remember learning that word, or did you know it before?

S: Yeah, I knew it.

I: Before the unit?

S: Yeah.

I: Do you remember how you found out about slips?

S: Um..um...well, if there's...ch, you would call it a landslide ..thats the proper name for it, a landslide. If you get a bit of ice and you roll it down a hill and it gets bigger and bigger and thats kind of like sliding, and, um... if a boulder does that and it all causes all the little other stones to slip down the side of the hill..

I: You knew that before the unit?

S: Yeah.

4.2 Claims to Have Deduced the Answer Child claims that the answer was worked out from previously held knowledge and denies that anything relevant was learned during the unit. As in the above case, the item was incorrect on the pretest and correct on the immediate post-test.

Example: (Item on the reasons for preventing erosion)

S: Um, because it, it takes away the growing soil. We need soil to grow things in, and, um, it takes the soil down to the sea and it, and, um, if we get anymore erosion the sea might go over, flood over and that will be the end of New Zealand.

I: Do you remember learning that in the unit?

S: No.

I: Talking about that?

S: No.

I: You just worked that out?

S: Yeah.

I: So you just sort of logically worked that one out.

S: Yeah, logic explanation.

I: I see.

4.3 Partial Claim to Have Deduced Answer In this case the child claims to have worked out the answer from prior knowledge, and also acknowledges some memory for the class. The implication is,

however, that the memory for the class discussion was not the real reason for the answer.

Example: (Item on the 'food chain')

S: Because the sheep eat grass and makes them nice and plump and then poor old sheep get slaughtered and the meat ...

I: Did Mr H. talk about food chains?

S: Yeah, he did.

I: Did he tell you about this or had you learned it before?

S: It's just my general knowledge, I suppose. I can't remember where I learned it ... Mr H., T-V or Mum ...

5. MISTAKEN RESPONSE. In this case the child put the wrong answer on the test immediately after the conservation unit and has been classified as not having learned the information. However the answer given during the interview and all the other information available from the interview suggest that the child did, in fact, learn the correct answer. Hence the probable inference that the incorrect answer on the second test was accidental.

Example: (Item on the amount of water needed to produce a kilogram of meat)

The best example here is the one given as an example of recall of specific details of class discussion (9.2 in Appendix A, p.A.8 above). In this example, the answer is so clearly recalled from class discussion that it is surprising the child got the answer incorrect on the immediate post-test. The item was, however, correct on the third post-test one year later.

Example: (Item on meaning of the word 'vegetation')

I: How did you know that? Where did you learn that?

S: When I was in Mr H's class.

I: Did he discuss that?

S: I think so. I'm not quite sure that's how I learnt that.

I: Would you have known that before?

S: No. I wouldn't have known what vegetation means.

APPENDIX D

EXAMPLE OF RECALL AND DEDUCTION PROCESSES USED IN ANSWERING AN ACHIEVEMENT TEST QUESTION

A question in the achievement test provided a list of 24 animals and birds and asked the students to place a tick beside "the animals and birds which are native to New Zealand". In the interview, the student 'A' has a blank copy of the test in front of her.

Interviewer: Right, now, how did you know which animals and birds were native to New Zealand? How did you choose them? You go through and tell me just how you chose them.

Student: Well, the kiwi, well, um ... well I just knew it.

Interviewer: What about the bush rat?

Student: No.

Interviewer: Wood pigeon?

Student: Yes.

Interviewer: Ferret?

Student: No.

Interviewer: Lizard?

Student: No.

Interviewer: Bat?

Student: No.

Interviewer: Opossum?

Student: Yes.

Interviewer: How did you know?

Student: Well, um, the unit in the library.
(Note: This student had studied the opossum using reference books in the library).

Interviewer: You found out ... What does it mean to be native to New Zealand?

Student: Um ... I'm not sure.

Interviewer: So, how did you guess them? How did you work them out?

Student: Well, um, I just knew what animals were native ...

Appendix D continued

Interviewer: So, you've got an idea of what native means, but you're not sure? What do you think it might mean? Why did you decide a ferret's not native and a wood pigeon is?

Student: Ah ... well, a ferret is sort of ... like, there's quite a lot of them.

Interviewer: Yeah, I see ... What about a rabbit?

Student: No.

Interviewer: It's not native? Why?

Student: Well ... there's quite a lot of them.

Interviewer: I see. How did you decide the Takahe was native?

Student: Um ... because there's not many left.

Interviewer: I see. Right ...

In this example, the student seems to be using a mixture of recall and deduction. The kiwi and the opossum seem to have been classified on the basis of memory ("I just knew it" "the unit in the library") while the other animals seem to have been classified according to the student's concept of 'native' (uncommon) and knowledge of the animals prevalence. However, the student's actual performance (17 out of 24 correct) suggests that memory is playing a stronger role than is apparent on the surface. It seems most likely that the student is using both recall and an attempt to develop a concept of 'native' which fits her existing partial knowledge, and will allow her to work out the right classification for the animals she doesn't know. Although her concept is wrong it is sufficiently effective to give her a good score on this set of items. It is tempting to describe the question-answering process for this student on this set of items as an example of 'concept formation'.

APPENDIX E

POST-TEST 1980

Name: _____

Class: Standard _____

Teacher this year _____

Teacher last year _____

Now we are going to try some examples. Listen carefully until I have read all the possible answers then circle the letter beside the correct answer.

Example (1)

St Albans is a suburb of

a) Auckland

b) Christchurch

c) Dunedin

d) I don't know

Now try another example:

Example (2)

Summer, winter, autumn and spring are

a) years

b) months

c) seasons

d) I don't know

PLEASE WAIT UNTIL YOU ARE TOLD YOU MAY TURN OVER

CONSERVATION TEST

1

PART ONE: EROSION

1) We use the word 'environment' to describe:

   a) the place around us
   b) a great deal of pollution
   c) very noisy places
   d) I don't know

2) We use the word 'erosion' to describe:

   a) the different levels of soil on a riverbank
   b) the wearing down of something
   c) ways in which pollution can be prevented
   d) I don't know

3) When water freezes into ice it:

   a) expands or takes up more space
   b) takes up the same amount of space as before
   c) gets smaller or takes up less space
   d) I don't know

4) As a boulder moves around in its journey from the mountain down the river it becomes:

   a) sharper and more jagged
   b) no different because boulders are very hard
   c) smoother and smaller
   d) I don't know

5) A good way to slow down or stop erosion in the mountains is to:

a) introduce animals from another place

b) plant lots of trees

c) lay out tar-sealed roads

d) I don't know

6) Farming has been a major cause of erosion in New Zealand because farmers:

a) use machines which run on oil fuel

b) have destroyed much of the native bush and vegetation

c) export or send our produce overseas

d) I don't know

7) The word 'deforestation' means:

a) planting trees to make a forest

b) cutting down all the trees in a forest

c) clearing away the little trees in a forest

d) I don't know

8) Which of these animals has been a major cause of erosion in New Zealand forests:

a) sheep

b) deer

c) rabbits

d) I don't know

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9) The path where stones and earth have tumbled down a mountainside is called a:

a) race
b) spur
c) slip
d) fall
e) I don't know

10) When we say an animal has been 'introduced' we mean it:

a) is a native animal
b) lives only in bush country
c) came from another country
d) I don't know

11) Rain can cause erosion by:

a) making the plants grow too fast
b) making the rivers flood over their banks
c) keeping the sun away from the grass
d) I don't know

12) Erosion in the sandhills is caused mostly by:

a) hot sun
b) heavy rain
c) rabbits
d) strong winds
e) I don't know

13) What sort of hillsides are most likely to be eroded:

a) bare hillsides

b) grass-covered hillsides

c) tree-covered hillsides

d) I don't know

14) Which agent of erosion causes wide valleys in the mountains:

a) bulldozers

b) glaciers

c) wind

d) skiers

e) I don't know

15) When a native forest is cut down:

a) it takes many years for the trees to grow again

b) it takes several months for the trees to grow again

c) the trees don't grow again because there is no shelter

d) I don't know

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16) Who has been fighting against the destruction of the forest at Southern Okarito?

a) the Native Forest Action League
b) the Ministry of Agriculture and Fisheries
c) the Government
d) the Trade Unions
e) I don't know

17) Erosion is caused by:

a) people
b) animals
c) weather and water
d) all of the above: people, animals, weather and water
e) I don't know

18) Why do we want to stop erosion?

a) it makes the mountains look ugly
b) it makes the ground very muddy
c) it takes away the growing soil
d) it fills up the sea and makes it too high
e) I don't know

19) Tick the boxes besides those of the following which are agents of erosion:

☐	water	☐	fire
☐	plastic	☐	ice
☐	trees	☐	snow
☐	bicycles	☐	frost
☐	wind	☐	paper
☐	sun	☐	rain
☐	fog	☐	rivers
☐	gold	☐	sea

20) Give an example of erosion close to St. Albans:

_____

_____

What causes this erosion?

_____

_____

CONSERVATION TEST

7

PART TWO: POLLUTION

1) Pollution is mainly caused by:

   a) storms
   b) people
   c) animals
   d) earthquakes
   e) I don't know

2) The amount of air around our world could be described as:

   a) infinite
   b) finite
   c) nobody knows if it is infinite or not
   d) I don't know

3) What do plants take in from the air:

   a) hydrogen
   b) oxygen
   c) carbon dioxide
   d) carbonic air
   e) I don't know

4) What do plants give out into the air:

   a) hydrogen
   b) oxygen
   c) carbon dioxide
   d) carbonic air
   e) I don't know

5) Which of the following words describes one kind of water pollution:

a) smog
b) erosion
c) effluent
d) flora
e) I don't know

6) How much of the earth's water is usable for man to drink?

a) less than one per cent
b) about a quarter of all the earth's water
c) about a half of all the earth's water
d) I don't know

7) Water is necessary for:

a) all living things
b) most living things
c) some living things only
d) I don't know

8) The water we use everyday comes mostly from:

a) evaporation
b) run-off
c) precipitation
d) I don't know

9) How much water is needed to grow the grass to feed the animals to produce one kilogram of meat:

a) about five milk bottles full

b) about 50 litres

c) thousands of litres

d) I don't know

10) When we can make good use of something for a second time we call this:

a) secondary

b) preservation

c) regeneration

d) recycling

e) I don't know

11) Which of the following is the worst kind of pollution around the countryside:

a) rotting wood and leaves

b) muddy swamps

c) old plastic bottles and chemicals

d) old newspapers

e) I don't know

12) Which of the following causes the worst kind of pollution of our rivers and seas:

a) oil

b) dead fish

c) floating seaweed and driftwood

d) I don't know

13) The hydrological cycle is about:

a) soil

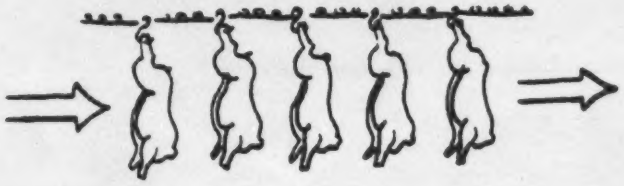
b) erosion

c) fire

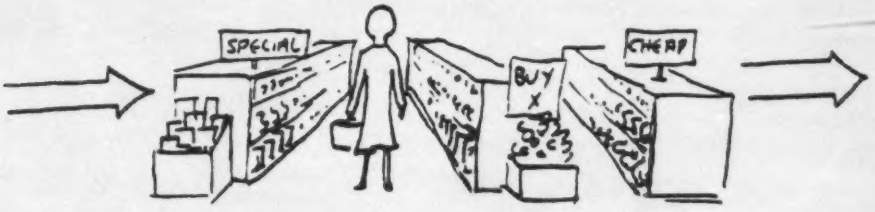
d) water

e) I don't know

14) Which of the following is a food chain:

a) 

b)

c) 

d) I don't know

15) How does the water leave the sea to get back on to land:

a) it goes up rivers

b) it's pumped in pipes

c) it evaporates and floats in clouds

d) it soaks under the ground

e) I don't know

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16) How do you feel about pollution:

a) I think it is a serious problem and it concerns me

b) I feel a little worried about pollution

c) I haven't really thought about it

d) I don't know

17) Can a very loud noise damage a person's hearing for the rest of their life?

a) Yes

b) No

c) I don't know

18) Do you think there is water underneath the ground under your school?

a) Yes

b) No

c) I don't know

19) Put a tick in the box beside each of the following which you think is a kind of pollution:

- [ ] flowers in a vase
- [ ] broken bottles in the river
- [ ] timber stacked in a timber yard
- [ ] smoke from a car exhaust
- [ ] a man in very old clothes
- [ ] a deafening noise from an aeroplane
- [ ] tree leaves lying beside the road
- [ ] smoke from a forest fire
- [ ] the roar of a strong wind
- [ ] people smoking
- [ ] litter
- [ ] children playing in the street
- [ ] pesticides and weedicides
- [ ] smog on a cold night
- [ ] cars lined up in a car park

20) Name two ways in which motorbikes can cause pollution when they are going down the road:

_____

_____

21) Name one kind of pollution that you would find in the St. Albans District:

_____

22) Name any one way in which you can help the problem of pollution:

_____

CONSERVATION TEST

13

PART THREE: ENDANGERED ANIMALS

1) When there are no more of a particular kind of animal left anywhere in the world, we say those animals are:

a) endangered
b) departed
c) extinct
d) untreated
e) I don't know

2) Which of these animals is in danger of dying out because it is hunted by man:

a) deer
b) opossum
c) dolphins
d) whales
e) I don't know

3) Which of these animals destroys the New Zealand bush and forests:

a) puma
b) wood pigeon
c) opossum
d) sheep
e) I don't know

4) Birds that live on the ground and cannot fly are easy to destroy because:

a) they can be seen easily
b) animals can eat their eggs
c) they are small
d) they cannot fight
e) I don't know

5) When we say that crayfish have been 'over-exploited' we mean that:

a) there are too many of them
b) there is not enough food for them
c) too many have been caught
d) they have grown too big
e) I don't know

6) The New Zealand Government has protected a great deal of our native forest by setting up:

a) National Parks
b) Sawmilling Companies
c) Tourist Resorts
d) An Agriculture Department
e) I don't know

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7) Most endangered animal species of New Zealand live in the:

a) ground

b) rivers

c) cities

d) native forests

e) I don't know

8) An endangered New Zealand bird is the:

a) thrush

b) kokako

c) pukeko

d) magpie

e) I don't know

9) Birds which cannot fly need to have:

a) tall trees to climb up

b) open spaces to run in

c) very light feathers

d) food near the ground

e) I don't know

10) We use the words 'life cycle' to describe:

a) how an animal moves around its environment to hunt and gather food

b) the way some animals go to sleep during the winter so they don't need so much food

c) the way an animal changes from a baby to an adult

d) I don't know

11) How does coal mining endanger some animals:

a) the smoke from the coal suffocates these animals

b) the coal pollutes the ground and kills the animals

c) when the forest is cleared for the mines the animals lose their homes

d) I don't know

12) When we talk about native fauna we mean:

a) native plants

b) native animals

c) native rivers

d) baby deer

e) I don't know

13) What do we mean by 'vegetation':

a) fruits and vegetables

b) all kinds of plants

c) all living things

d) soils and rocks

e) I don't know

14) Whey are there no dinosaurs left today?

a) Cavemen hunted and killed them all

b) they changed into modern animals like horses

c) they lost the ability to feed and protect themselves

d) they just disappeared for no reason

e) I don't know

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15) The Government is protecting the toheroas by:

a) growing them on toheroa farms

b) stopping people from taking too many

c) telling people that toheroas are dangerous

d) putting fences round their breeding grounds

e) I don't know

16) Oil spillages in the sea are very bad for fish because the oil:

a) changes the colouring of the fish

b) blinds their eyes

c) poisons their food

d) keeps the sun off the fish so they become chilled

e) I don't know

17) Do you think it would matter if all the elephants died out and there was none left:

a) Yes. Why? _____

_____

b) No. Why? _____

_____

c) I haven't any strong feeling about this.

18) Put a tick beside the animals and birds which are native to New Zealand:

☐	kiwi	☐	sheep
☐	bush rat	☐	mountain goat
☐	wood pigeon	☐	pukeko
☐	ferret	☐	fantail
☐	lizard	☐	cat
☐	bat	☐	deer
☐	opossum	☐	man
☐	kotuku	☐	dog
☐	rabbit	☐	thrush
☐	tuatara	☐	takahe
☐	wild pig	☐	quail
☐	stoat	☐	bell bird

19. Give the names of two animals which live outside New Zealand and are in danger of dying out:

_____

_____

20. Do you think there will ever be a time when there are no people left anywhere in the world.

a) Yes

b) No

Why do you think so? _____

_____

_____

Circle the letter beside the phrase which best describes how you felt about the test. Then in the space beside write down why you think you felt that way.

a) Very difficult because _____

_____

_____

b) Hard because _____

_____

_____

c) Not too hard because _____

_____

_____

d) Easy because _____

_____

_____

THANK YOU